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THE JOURNAL

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

JANUARY 1912

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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MONTHLY MEETINGS: NEW YORK, JANUARY 9; BOSTON, JANUARY 15

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OF

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MEETINGS OF THE SOCIETY

NEW YORK MEETING, JANUARY 9

The members of the Society resident in New York will hold a meeting January 9 to consider the work of the Society for the current year and their own share in it. Never in the history of the Society have its activities been extended in so broad and useful a way as at the present time. At this meeting members of the several Standing Committees and of the Committee on Meetings in New York will give informal talks upon the plans under way.

The meeting will be opened by the chairman of the New York Committee, with a statement as to the subject of the meeting and what it is desired to accomplish. He will be followed by President Humphreys who will talk upon the recent activities of the Council. Charles E. Lucke will then speak upon the work of the Committee on Meetings; F. A. Waldron on some problems before the New York Committee, on which opportunity for discussion will be given; R. M. Dixon on the finances of the Society; G. J. Foran on the problem of membership; F. R. Low on publications; Leonard Waldo on the Society's library; and Edward Van Winkle on the business of the House Committee. All these remarks will be brief and will cover the ground as fully as possible in a limited space of time.

The meeting will constitute a general get-together of the New York members to consider future plans with relation to their part in the activities of the Society, and a large attendance is anticipated on so important an occasion.

BOSTON MEETING, JANUARY 15

The annual dinner of the members of the Society and of the Boston Society of Civil Engineers and the Boston Section of the American Institute of Electrical Engineers will be given on January 15, 1912, at the Hotel Somerset. The Boston Society of Civil Engineers will have charge of the meeting and committees are actively at work on the arrangements. Addresses will be made by officials of the three organizations represented.

BOSTON MEETING, DECEMBER 20

A meeting of the Society with the Boston Society of Civil Engineers and the Boston Section of the American Institute of Electrical Engineers was held in Boston on December 20, the electrical engineers presiding.

The paper of the evening, Electric Propulsion of Ships, was read by the author, W. L. R. Emmett, engineer of the lighting department of the General Electric Company, Schenectady, N. Y. Mr. Emmett, who is eminently qualified to discuss this subject and who served many years in the Navy, gave a detailed description of the various methods of propulsion in use in marine work at the present time, and showed where the system which he proposed, viz., turbines, generators and motors, was by far the most economical from the standpoints of saving in fuel, in engine room space, weight of machinery, etc. He stated that for a number of years past the General Electric Company had been trying to get the United States Navy Department to give his system of electric propulsion a trial on one of their large ships, and that the contract had at last been awarded to equip one of the large colliers now building with their apparatus. Mr. Emmett expects to have the apparatus which will be used on the ship set up in the factory and tested out under conditions as nearly similar as possible to those which will be met with in service, and believes he will be able to show how much more economical its operation is than that of any other equipment. He further outlined the details for equipping some of the large battleships and ocean liners with electric propulsion, and explained in detail the gearing system for use on ships and the difficulties which would be encountered with it. His remarks were illustrated by lantern slides.

The paper was discussed by I. N. Hollis of Harvard University and C. H. Peabody of the Massachusetts Institute of Technology.

CURRENT AFFAIRS OF THE SOCIETY

To emphasize the national character of the Society and to indicate the Society's interest in its individual members, the Secretary will make a tour during the month of January which will include most of the cities where meetings of the members are held and as many as possible of the student branches located in the various universities and institutes. The Secretary will represent on this trip the officers of the Society and will tell the members of the work in hand and contemplated.

The plans include the following points and events: January 3, meeting of the Buffalo members, to be addressed by the Secretary and by John Calder, the latter speaking on Economic Management of Industrial Establishments; January 4, visit to the Ohio State University Student Branch; January 5, visits to student branches at the University of Cincinnati, and the University of Kentucky at Lexington, Ky.; January 6, meeting of the members in St. Louis and visit to Washington University, St. Louis; January 7, visit to the University of Missouri, Columbia, Mo.; January 8, visit to the University of Kansas, Lawrence, Kansas; January 9, visit to University of Nebraska, Lincoln, Neb.; January 10, meeting of Denver members; January 16, visit to Leland Stanford Jr. University, Palo Alto, and the University of California, Berkeley, Cal.

On January 15 the Secretary will attend the meeting of the representatives of national engineering organizations, called in San Francisco, Cal., to consider plans for an Engineering Congress which is proposed for 1915, in connection with the Panama-Pacific Exposition to be held in that year to commemorate the opening of the Panama Canal.

On the return trip, the Secretary will stop at the following points: Iowa State College, Ames, Ia.; University of Iowa, Iowa City, Ia.; St. Paul; University of Wisconsin, Madison, Wis.; Chicago; Purdue University, Lafayette, Ind.; Cleveland; Pittsburgh; and Pennsylvania State College, State College, Pa.

Calvin W. Rice, *Secretary*

ANNUAL MEETING

The thirty-second Annual Meeting of the Society, one of the largest and most enthusiastic of its history, was held at the Society Headquarters in New York, December 5–8, 1911. The feature of this year's meeting was the extraordinarily large average attendance, the total registration exceeding 1200, with 687 members and 545 guests in attendance at its various gatherings. The Committee on Meetings had prepared a program of unusual interest, comprising contributions from three of the new sub-committees recently appointed to investigate special subjects, and all the sessions were well attended and brought out discussion of value. On Wednesday evening the address by Dr. Robert S. Woodward, of the Carnegie Institution of Washington, was much enjoyed by all in attendance, and appreciation was expressed of Dr. Woodward's courtesy in consenting to address the membership. Interesting and varied technical excursions and the splendid entertainment features arranged by the Committee on Meetings in New York, assisted by the Ladies' Reception Committee, formed a social background to the meeting and contributed to the spirit of fellowship which prevailed.

OPENING SESSION, TUESDAY EVENING

Following the successful arrangement of previous years, the President's Reception was held in the rooms of the Society on Tuesday evening. This was preceded by a meeting in the auditorium where E. D. Meier, retiring President, delivered the presidential address, entitled, The Engineer in the Future, in which he briefly sketched the engineering achievements of the past and predicted great opportunities and responsibilities for the future.

A portrait of Colonel Meier was then presented to the Society by Walter M. McFarland, who expressed his regret at the absence of Mr. C. J. H. Woodbury, who had been so instrumental in arranging for the gift and the presentation. He reminded the membership of President Meier's professional and military record, and said that the presentation of this portrait was the completion of the tribute paid to Colonel Meier at the Pittsburgh meeting last Spring, when an engrossed set of resolutions was offered to him on the occasion of his seventieth birthday. He expressed the hope in conclusion that Colonel Meier might for many years continue active in the Society and that he might have increased happiness and prosperity.

Colonel Meier responded with a few brief words of thanks and called on Theodore Stebbins, Chairman of the Tellers of Election of Officers, to make the report of the election. The following result of the ballots cast was given: President: Alex. C. Humphreys; Vice-Presidents: Wm. F. Durand, Ira N. Hollis, Thos. B. Stearns; Managers: Chas. J. Davidson, Henry Hess, George A. Orrok; Treasurer: Wm. H. Wiley. George Westinghouse, Geo. W. Melville and Fred. W. Taylor, Past-Presidents of the Society, were appointed to escort Dr. Humphreys to the platform, and an introductory speech was made by Colonel Meier outlining Dr. Humphreys' career and describing him as a typical engineer, a man not afraid of work and who loved his work. He spoke also of his international reputation as the foremost specialist in the gas industry and of the honor he had received at the hands of Stevens Institute and other universities and colleges. He expressed the belief of all, in conclusion, that Dr. Humphreys might safely be intrusted with the affairs of the Society which he would be sure to handle in a way of which the Society might be proud.

Dr. Humphreys in his reply spoke of his appreciation of the honor conferred upon him and of his recognition of the responsibility which it entailed, and said he liked to think of the Society as organized within the walls of the first college devoted distinctly to the study of engineering, and that its first President was then an instructor in that institution.

The audience then proceeded to the rooms of the Society, which had been appropriately decorated for the occasion, where the membership met the new officers and renewed acquaintance with one another. Music was rendered during the evening and a collation was served. George J. Foran acted as Chairman of the sub-committee in charge of the reception.

WEDNESDAY MORNING, BUSINESS MEETING

The first professional session of the convention opened on Wednesday morning in the auditorium with the annual business meeting. Vice-President Baker presided in the absence of the President.

The report of the Tellers of Election to Membership was read by the Secretary, announcing the admission of 187 new members and the promotion of 17.

The Annual Report of the Council was read by the Secretary, and during the reading of the resolutions upon the death of Charles Wallace Hunt, incorporated in it, the entire audience rose and paid a silent tribute to his memory. In connection with the report, the Secretary spoke of the necessity of growth in a Society with activities covering so great a scope, and said he was glad to state that the resources of the Society were now nearly three-quarters of a million dollars, the only indebtedness being the certificates held by the membership, which would be redeemed as rapidly as possible.

The Chairman happily termed the meeting that of the stockholders in a business corporation, the Council being the Board of Directors, and reminded them that this occasion presented an opportunity for criticism. The fact that the members now had no mortgage on their home was due, he said, in no small part to Charles Wallace Hunt.

The following amendment to C 21 of the Constitution, proposed by the New York Committee on Meetings at the Spring Meeting in Pittsburgh, was then considered:

> Members of all grades residing in New York and vicinity and represented by the Committee on Meetings in New York City, should have the privilege and authority by majority vote of such membership to increase their annual dues by the sum of $3, such increase to be applied to financing such entertainment features of the Annual Meetings in New York City and its own local meetings as their Committee on Meetings in New York City may elect.

Jesse M. Smith, Chairman of the Committee on Constitution and By-Laws, proposed the following amendment to this amendment:

> The expense of all meetings of the Society, and any group or section thereof, shall be arranged in accordance with such By-Laws and Rules as the Council may from time to time adopt, provided, however, that nothing in this section shall be construed to authorize the Council to make any increase of annual dues of members in any grade.

The motion was seconded by George M. Brill, and a discussion ensued in which a large number participated. Walter Rautenstrauch, Chairman of the New York Committee on Meetings, said that his committee believed the amendment proposed at the Pittsburgh meeting represented the wishes of the membership resident in New York, since a recent canvass indicated a strong desire to substitute an increase of dues for the yearly assessment plan. A number then expressed themselves in favor of the amendment as proposed by Mr. Smith, and it was suggested that the Society should make an assessment from its funds so that the burden might not fall so heavily upon any one section of the membership. This, Dr. Humphreys pointed out, would not be possible in view of the proposed enlargement of the Society's operations for which its present income would be insufficient. The majority seemed to agree that the entertainment features should not be omitted, and several spoke of the profit to be gained from mutual acquaintance among men of affairs, who talked more freely of their work on social occasions than they could be persuaded to do at professional meetings.

The amendment proposed by Jesse M. Smith was finally adopted as a substitute for that proposed by the New York Committee, and it was voted to send this amendment out to the entire membership for letter ballot.

WEDNESDAY MORNING SESSION—PROFESSIONAL PAPERS

Three papers were discussed following the business meeting at the Wednesday morning session. The first of these, The Turret Equatorial Telescope, by James Hartness of Springfield, Vt., dealt with a new type of astronomical observatory designed to protect the observer from cold. A revolving turret for the polar axis of the instrument is used for this purpose, making the instrument and building integral. The paper was discussed by W. R. Warner, Ambrose Swasey, William Kent, Henry Hess and F. R. Hutton.

Sterling H. Bunnell of New York then presented his paper on Expense Burden: Its Nature and Incidence, which dealt with the correct distribution of burden items over the various producing units of the factory, thus stabilizing the cost of product against the effect of temporary changes in the expense schedule, while providing a definite standard of running expense as a measure of the efficiency of the supervising department. This was discussed by H. F. Stimpson, Harrington Emerson and B. A. Franklin.

Standard Cross-Sections by H. deB. Parsons of New York was next presented by the author, and pointed out the advantage of a uniform method for cross-sectioning drawings so as to indicate graphically the materials. This was discussed by F. DeR. Furman.

WEDNESDAY AFTERNOON—PROFESSIONAL SESSION

Following a luncheon served on the fifth floor of the Engineering Societies Building, a second professional session was held in the auditorium, commencing at 2 o'clock, at which a paper by D. S. Jacobus, of New York, on Tests of Large Boilers at the Detroit Edison Company, was presented by H. O. Pond of New York, in the absence of the author. This paper describes tests made on two boilers at the plant of the Detroit Edison Company, one being fitted with Roney Stokers and the other with Taylor stokers. The paper was discussed by R. H. Rice, R. D. DeWolf, H. O. Pond, W. D. Ennis, D. C. Johnson, H. deB. Parsons, H. H. Esselstyn, E. G. Bailey, Wm. Kent, R. C. Carpenter, J. C. Parker, E. J. Billings, W. F. M. Goss, E. D. Dreyfus, Mr. Thomas and H. G. Stott.

James E. Howard of Washington, D. C., presented his paper on Strain Measurements of Some Steam Boilers under Hydrostatic Pressures, giving hydrostatic tests made upon two horizontal tubular boilers which had been in service for a period of 27 years, and showing the strains occurring at the locations where measurements were taken. This was discussed by Mr. Allen.

A paper contributed by the sub-committee on Machine Shop Practice, Herringbone Gears, with Special Reference to the Wuest System, was presented by its author, Percy C. Day of Milwaukee. The Wuest System, founded and developed in England to a high degree of perfection within recent years, has made possible the production of this type of gears with the requisite speed and accuracy. The paper was discussed by F. E. Rogers, F. DeR. Furman, L. D. Burlingame and W. C. Brown.

SIMULTANEOUS SESSION, CEMENT MANUFACTURE

A simultaneous session was also held on Wednesday afternoon arranged by the sub-committee on Cement Manufacture. Six papers were presented, illustrated by lantern slides. These included, Confirmation of the Advantages of Electricity to the Cement Manufacturer, by J. B. Porter of Philadelphia, giving a résumé of information on the subject obtained from various cement manufacturers; and Electrical Power in Cement Plants, by F. H. Lewis, Birmingham, Ala., which offered further facts along the same line. Both papers were discussed by Mr. Pratt, Mr. Wylie, H. J. K. Freyn, H. Struckmann, H. S. Spackman and Mr. Dudley.

Two papers on prevention of accidents in cement plants were then presented, Protection of Laborers from Accidents and Injury to Health in Cement Plants, by Otto Schott of New York, and Methods and Appliances for Prevention of Accidents in Cement

Plants, by J. G. Bergquist of Buffington, Ind. There was no discussion.

A paper was then presented by the author, Holger Struckmann, on Depreciation and Obsolescence in Portland Cement Plants, which was discussed by H. S. Spackman and Mr. Higgins. Dr. Schott presented a second paper on The Dust Problem in Portland Cement Plants, which offered various methods of solution of this very important problem. This was discussed at length by Mr. Mason, H. S. Spackman, J. G. Bergquist, J. B. Porter, W. B. Ruggles and Mr. Brown.

WEDNESDAY AFTERNOON RECEPTION

On Wednesday afternoon the Ladies' Reception Committee, Mrs. Jesse M. Smith, Chairman, entertained the membership and their guests in the Society rooms, at an informal reception, in which a large number participated. Music was rendered throughout the afternoon and refreshments were served. Although on similar occasions in previous years the hospitality of the ladies had been greatly appreciated, this year's reception was considered the most successful of all.

WEDNESDAY EVENING

On Wednesday evening Dr. Robert S. Woodward, President of the Carnegie Institution of Washington, D. C., gave a fascinating address on Geo-Dynamics. Dr. Woodward said that more is known about the earth than about any other body, and spoke of its shape, its area of 196,940,000 sq. miles, its volume of 259,880,000,000 cu. miles, and the four parts into which it is divided, the atmosphere, hydrosphere, lithosphere and centrosphere. The total mass of the earth is 6600 by 10^{18} tons and it is covered with crust to a depth of 10 miles, which is represented by 23 by 10^{18}. Of this crust 50 per cent is oxygen, 25 silicon, 7 aluminum, and 5 iron. The crust of the earth rests on its nucleus as if the whole mass were fluid, and the internal pressures are therefore substantially hydrostatic. Its density increases from about 2.75 at the surface to about 11 at the center, and its pressure from zero to about 3,000,000 atmospheres. The amount of internal heat of the earth escaping each year is sufficient to melt 800 cubic miles of ice. A million years seems to be the smallest convenient unit of time which can be used in reckoning the age of the earth. The kinetic energy of translation of the earth equals 63,200 by 10^{30} foot-pounds; and of the rotation of the earth, 157 by 10^{27} foot-pounds. The first of these is 400,000 times the second and is more than will be developed at Niagara at the present rate of about 5,000,000 horsepower in a million million years. The effects of the earth as a timekeeper are shown in secular cooling, meteoric dust, tidal friction, the shifting of surface load, and Maxwell's meteorite. Dr. Woodward also spoke of the origin of the earth, outlining the nebular hypothesis, the theory of meteoric dust and the argument from the moon.

The lecture was well attended and brought out many expressions of commendation and interest.

THURSDAY MORNING, PROFESSIONAL SESSION

At the professional session called to order in the auditorium on Thursday morning four papers were presented. The first, The Core-Room: Its Equipment and Management, was read by the author, Henry M. Lane of Cleveland, Ohio, and dealt with the subject of foundry cores and core-room practice, particularly core-room location and arrangement, core sands and binders, the selection and compounding of core materials, core ovens and drying, core pasting, handling and storage, and core machines and core-room rigging. It was discussed by A. E. Outerbridge, T. D. West, A. N. Kelley, B. D. Fuller, H. A. Becker and E. H. Mumford.

Tests of a Sand-Blasting Machine, by Wm. T. Magruder of Columbus, Ohio, was presented by the author, and gave the records and results of quantitative tests of such a machine under the actual conditions of commercial practice. The paper was discussed by F. C. Brooksbank, J. M. Betton, W. S. Giele, A. G. Warren and S. C. Smith.

A paper by Amasa Trowbridge of Hartford, Conn., on Die Castings, was then presented. The paper summarizes briefly the state of the art of making small castings in steel molds and outlines the principles for this process of casting and of hand and automatic casting machines.

Variable-Speed Power Transmission, by George H. Barrus of Boston and Charles M. Manly of New York, was read by Mr. Barrus, in which was described a mechanism called the Manly Drive and a series of efficiency tests made on it. The mechanism is fundamentally a hydraulic device and the fluid used is ordinary machine oil. After the presentation of the paper Mr. Barrus gave a practical demonstration of variable-speed power transmission by means of a Manly Drive equipment erected on the platform.

SIMULTANEOUS SESSION, GAS POWER SECTION

A session of the Gas Power Section was also held on Thursday morning. R. H. Fernald, Chairman of the Section, presided and read the annual address on The Gas Power Field for 1911, in which he outlined graphically the rapid progress which is being made. Announcement of the newly elected officers was then made by the Tellers of Election, as follows: Chairman, H. J. Freyn; Secretary, George A. Orrok. Mr. Freyn was escorted to the chair by F. R. Low and made a brief speech of thanks.

The meeting then proceeded to the consideration of professional topics, and H. R. Setz of Warren, Pa., presented his paper on Oil Engines, in which he described the Diesel engine and its modifications, commonly known as constant-pressure engines, and explained the principles underlying the various processes of fuel injection.

A paper by Forrest M. Towl of New York, on the Test of an 85-H.P. Oil Engine, was presented by the Secretary. This described a test of a De La Vergne engine, FH type, operating an oil pump, and one of the same engine under the same conditions but with the load applied by a prony brake instead of a pump. The papers were discussed together by C. E. Sargent, A. J. Frith, L. K. Doelling, L. B. Lent, Wm. Sangster, James Craig, L. P. Breckenridge and H. J. K. Freyn.

W. D. Ennis of Brooklyn, N. Y., then presented his paper on Design Constants for Small Gasolene Engines, in which an attempt to develop a more general expression than the common rating formulae which consider piston displacement as the only variable and which shall include the effect of piston speed variations, was described.

E. D. Dreyfus of East Pittsburgh then presented a paper on A 1000-Kw. Natural Gas Engine: Tests, Construction and Working Costs, prepared by himself and V. J. Hultquist of New York, in which was described the testing of a large gas engine in commercial service, with the economies realized in both construction and operation. The paper was discussed by W. D. Ennis, I. E. Moultrop and G. A. Orrok.

The session concluded with a vote of thanks to the officers and committees for their faithful and untiring work and successful endeavors of the year which had elapsed.

THURSDAY AFTERNOON, INSPECTION OF THE OLYMPIC

About 500 members and guests visited the S.S. Olympic on the invitation of the White Star Line on Thursday afternoon. As this was the first trip made by the giant vessel since her accident some months ago, she was an object of especial interest. Through the courtesy of the ship's officers and guides detailed by them, the members had an excellent view of the splendid appointments of the vessel and of the many conveniences for comfortable traveling which have been incorporated into this literal floating palace. Although the Olympic was delayed in starting on her trip and did not dock at the Chelsea pier until Thursday morning, the guests were made welcome most adequately and offered every possible assistance in their inspection of the boat.

THURSDAY EVENING, REUNION

On Thursday evening the grand ballroom at the Hotel Astor was the scene of a brilliant gathering at the annual reunion of the Society, given by the New York members to the visiting membership and their guests. Dancing commenced at nine o'clock and was largely participated in, although a number occupied the boxes with which the ballroom abounds. The New York Committee, assisted by a sub-committee, F. A. Scheffler, Chairman, had arranged novel features for the occasion, such as lighting effects during the dances, and expressions of admiration at the result of these ingenious innovations were heard on every hand. Refreshments were served throughout the evening and a royal welcome extended to all.

FRIDAY MORNING, PROFESSIONAL SESSION

The concluding professional session of the convention was held on Friday morning in the auditorium, and was exceptionally well attended. A paper contributed by the sub-committee on Textiles entitled The Development of the Textile Industries of the United States, by Frank W. Reynolds of Boston, was presented by Albert L. Pearson, of the same city, and gave a general statement of present conditions, covering the field in a very adequate and illuminating way. The great development in these industries has led to the concentration of engineering skill upon construction, power, machinery, and general plant arrangement, so that the general efficiency of modern mills is high, but there are yet many unsolved problems which seem to depend largely upon the mechanical engineer. The paper was discussed by E. D. Dreyfus, C. T. Main, G. R. Stetson, Mr. Eccles, G. H. Perkins, C. F. Scott, A. J. Herschmann, J. A. Pratt, W. L. Lyall, G. M. Brill, Dwight Seabury, Calvin W. Rice, G. H. Perkins, and Mr. Willister.

Two papers on air conditioning were then presented by the author, Willis H. Carrier of Buffalo, N. Y., Rational Psychrometric Formulae: Their Relations to the Problems of Meteorology and of Air Conditioning; and Air-Conditioning Apparatus. In the latter paper F. L. Busey of Buffalo acted as joint author. Both papers, which supplemented one another, dealt with the artificial regulation of atmospheric moisture, and gave a theoretical discussion of the subject, developing formulae for the solution of problems. They were discussed by R. C. Carpenter, L. S. Marks, H. E. Longwell, O. P. Hood, R. C. H. Heck, J. I. Lyle, F. R. Still, Thos. M. Gunn and H. M. Prevost-Murphy.

A paper on Some Experiences with the Pitot Tube on High and Low Air Velocities, was then presented by the author, Frank H. Kneeland of Gary, W. Va., which related to the use of the Pitot tube for the measurement of flow of large volumes of air and tests made at the plant of the United States Coal and Coke Company at Gary. The paper was discussed by G. D. Gebhardt, R. C. Carpenter and W. H. Carrier.

At the conclusion of the session, the following resolutions of thanks were offered and unanimously adopted:

Whereas the members and guests of The American Society of Mechanical Engineers at the Annual Meeting, December 1911, have again been accorded opportunities for participating in professional sessions of unusual merit and in the entertainment provided by the New York membership,

Be It Resolved that on behalf of the visiting members and guests the Secretary extend the thanks of the Society to the Committee on Meetings for the excellence of this convention; to the Committee on Meetings in New York and the Ladies' Committee for the pleasure afforded by the various entertainment features; to Dr. R. S. Woodward for his instructive and illuminating lecture; to the officials of the White Star Line and the officers of the S.S. Olympic for the privilege of visiting this latest and largest transatlantic liner; to Thomas A. Edison, Honorary Member of the Society; and to the following firms and public works, from whom cordial invitations were received to visit their plants: Bush Terminal Company, Brooklyn, N. Y.; Brooklyn Navy Yard; E. W. Bliss Company, Brooklyn, N. Y.; J. H. Horton Ice Cream Company, New York; Ward Bread Company, Brooklyn, N. Y.; and the Hotel Astor, New York.

EXCURSIONS

Through the efforts of the Excursion Committee, Walter Rautenstrauch, Chairman, a number of interesting and enjoyable excursions to technical points were made on Friday afternoon.

About 150 members and guests were entertained at the Edison Laboratory, Orange, N. J., where they were personally welcomed by Mr. Edison, who is an Honorary Member of the Society. The party made the trip in a special car and dinner was served in the laboratory immediately upon their arrival. Millar Reese Hutchinson, one of Mr. Edison's engineers, gave a lecture on the construction and performance of the Edison storage battery, and presented to Professor Rautenstrauch, who conducted the party, the "key" of the laboratory, consisting of a copper wire in a test tube which Mr. Edison said was the key to many of his achievements. The visitors were conducted through the various parts of the works and were shown two inventions, publicly displayed for the first time, the improved phonograph placed within a cement case which gives better acoustic properties, and the kinetograph, a combination of moving pictures and phonograph. Mr. Edison also predicted the extensive use of reinforced concrete in the making of furniture, and showed his new home moving-picture outfit, which without the lighting device is no larger than an ordinary camera and can be carried in the pocket of the operator. The films used are so small that a picture on one of them is scarcely discernible by the naked eye and the process of their manufacture is so delicate that a speck of dust would ruin a picture. Moving pictures of the party entering the laboratory were developed during the visit and displayed to the guests before their departure. The film was presented to them as a memento of the occasion.

Some of the membership made a visit to the plant of the Bush Terminal Company in Brooklyn on Friday afternoon, and viewed the exceptional facilities provided for handling shipments, in addition to the provision made for their manufacture and storage. These comprise seven docks about 1400 feet long; special one-story warehouses for storing cotton and other fibrous materials; a series of six-story warehouses for storing miscellaneous materials, either in bond or free storage; a system of handling bulky freight over long distances, consisting of an electric drive truck, used to draw three or four loaded trailers; model fireproof lofts, about 100 acres in area, each building provided with a side track from a terminal railroad; and a well-arranged freight yard, having about 12 storage tracks with two diagonal series of switches or ladders reaching each individual track so that any car can be picked out of its place in the yard with the least amount of switching. All of the warehouses and loft buildings are provided with the sprinkler system and the lofts have steam heat and electric light and power.

The Brooklyn Navy Yard was also visited by a party of about fifty members and guests, under the guidance of George B. Preston, and were shown the various points of interest by Lieutenants A. A. Baker and A. L. Parsons of the civil engineering department. These included the power plant which generates all the electricity used, both for lighting and power, and which has recently been remodelled and extended, the reciprocating engines formerly in use being replaced by steam turbines; the engineering department machine shop where the main engines and steam auxiliaries of the battleship New York were in process of construction, and the foundry and boiler shops, full and interesting explanations of the work in progress being given in every case. After the inspection the party was conducted by Midshipman H. K. Lewis over the battleship Delaware, which was in dock, being overhauled, and had a very complete view of the vessel, including its method of operation and the sighting and firing of the 13 in. rifles. Full opportunity was given to the visitors to examine at their leisure the main engines, boilers and auxiliary steam equipment.

A smaller party visited the E. W. Bliss Company in Brooklyn, where they were conducted through the works by Mr. Bailey. The inspection included the engineering and drafting department, the assembling of the smaller sizes of punch presses, single and double action, the can-making machinery department, with its various automatic machines which eliminate handling as much as possible, the large press department where some double draw presses were in different stages of completion, and the die department with its wide range of work. Only the torpedo department where the Government work is done was omitted, as visitors are not permitted to see it. The trip proved most interesting and was enjoyed by all.

Godfrey M. S. Tait conducted a party through the J. M. Horton Ice Cream Company's Plant, New York, probably the largest suction gas plant in the country and the largest installation of gas producers ever allowed inside a factory building within the city limits. The gas producers are two in number and are each rated at 350 h.p., operating continuously 24 hours a day. Especial care has been taken to make this plant a model one, eliminating fire risks as much as possible. The party were very pleasantly entertained by the company.

About 30 members and guests enjoyed an interesting trip to the plant of the Ward Bread Company, recently established in Brooklyn, where modern methods for cleanliness and sanitation have been installed. The equipment consists of a complete system of bucket elevators and screw conveyors for transporting the flour from the storage bins in the basement to the weighing machines on the top floor. This is mixed in dough-mixing drums with water drawn into storage tanks from supply lines furnishing it of the desired temperature. The mixers are operated by individual motor drives, with automatic control for starting and stopping. When ready the dough is placed in tubs suspended on an overhead rail system and allowed to rise. It is molded and kneeded by machines of ingenious design, connected by a series of belt conveyors for carrying the prepared dough preparatory to placing in pans for baking. On the second floor there are three long rows of coal-fired ovens, fitted with steam jets for supplying moisture and equipped with a device for maintaining the desired temperature. The baked loaves of bread are carried by conveyors, passing in front of each row of ovens, and are delivered into the packing and shipping room on the first floor through open spiral chutes. It is then put into wagons from the shipping room which is entirely surrounded by an enclosed platform. Robert P. Schoenijahn conducted the party and a guide was detailed by the company to show the visitors about.

Throughout the convention the American Museum of Safety, located on the sixth floor of the Engineering Societies Building, was open to inspection by the membership. Models and photographs of safety devices to protect the lives of workmen and the public were on view and were explained by an attendant.

A Bureau of Information was conducted in the foyer of the building and data concerning time tables, points of amusement, hotels, etc., put at the disposal of the members. Walter Rautenstrauch acted as Chairman of the Bureau.

ENTERTAINMENT OF LADIES

The Ladies' Reception Committee, composed of ladies resident in and about New York, Mrs. Jesse M. Smith, Chairman, as usual contributed much to the pleasure of the convention. In addition to the reception given on Wednesday afternoon, in which both members and guests participated, trips were arranged to various points of interest to the visiting ladies. A Ladies' Guides Committee, Mrs. Charles R. Wight, Chairman, was in charge of this feature. On Wednesday morning a large number of ladies visited the Public Library where they were shown about by a guide detailed for the purpose by the library officials, and had a very complete view of the fine new building opened to the public in the spring of 1911. Through the courtesy of the John Wanamaker management, Thursday morning was very delightfully spent in visiting this large department store under the care of a special guide. A short concert was given in the auditorium and various other of the store's many facilities evoked to add to the pleasure of the party. On Friday morning an inspection was made of the Herter Looms, founded by Albert Herter, A. N. A., where some remarkable work in tapestry and similar decorative work is being done under Mr. Herter's personal supervision. Workmen have been brought from abroad and every effort is being made to produce domestic work which will vie with that being done in Europe. The visit proved most instructive and interesting.

In addition to these excursions, the ladies participated in the trip to the Olympic and to the Edison Laboratory and Ward Bread Company on Thursday and Friday afternoons. One of the guides held herself in readiness to accompany ladies to the two large museums which New York boasts, and others were prepared to show those who desired through the shops and other points of interest to visitors. Many ladies availed themselves of the opportunity to meet one another in the Ladies' Headquarters established in the rooms of the Society, and many expressed their appreciation of the Committee's hospitality.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The Student Branch of the Armour Institute of Technology held a meeting December 6, at which L. H. Philleo and J. D. Bradford presented a paper, Some Phases of Rotary Gas Engines. A proposed rotary gas engine designed by the authors was described in detail. The construction and operation of the engine were fully explained with the aid of numerous finished drawings of the details and assembled parts. In the discussion which followed, the advantages and disadvantages of rotary engines, as compared with those of the piston type, were taken up. The chief mechanical obstacles pointed out for an engine of this type were excessive friction of the moving parts and packing troubles.

COLUMBIA UNIVERSITY

At a meeting of the Columbia University Student Branch, November 23, Prof. F. R. Hutton lectured on the Prevention of Accidents.

CORNELL UNIVERSITY

The subject of Soldering was discussed before a meeting of the Cornell University Student Branch, November 1, by Professors Hess, Barnard, Wolff, Franck, Curtiss and Yoakum, and Mr. Matthews. On November 17, Professor Carpenter discussed the papers, recently published in The Journal, by W. H. Carrier, D. S. Jacobus and F. H. Kneeland.

On December 8, M. M. Upson delivered an address on Concrete Piles, Their Manufacture and Uses.

LEHIGH UNIVERSITY

At a meeting of the Lehigh University Student Branch in October, an interesting and instructive discussion took place on the subject of Aviation. A paper by James Bailey, The Practicability of Aeroplanes, divided the subject into four parts, safety, reliability, economy and utility and said that airships at present are neither safe nor reliable and are too expensive for commerce, but of great utility in military work. In his paper on Aerial Motors, H. B. Tinges gave a brief history of the development of aeronautical motors from the time of Sir Hiram Maxim's flights in 1894. A third paper on the subject of Aero-Dynamics was contributed by Nevin H. Guth.

Morris L. Cooke spoke on Scientific Management at a second meeting of the branch in October.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Mechanical Engineering Society of the Massachusetts Institute of Technology held a meeting November 23, when Irving E. Moultrop gave a talk on Power Plant Design, with special emphasis on the boiler room. He also explained in detail the arrangements at the L Street station of the Boston Edison Company.

OHIO STATE UNIVERSITY

Mr. S. Swarr told of his experiences with large waterwheels and pumping machinery while in the employ of the Platt Iron Works, Dayton, Ohio, at a meeting of the Ohio State University Student Branch, November 20. An abstract of Frederick W. Taylor's paper on the Principles of Scientific Management, made by A. I. Brown, was also presented. A discussion followed in which Professor Hitchcock and Messrs. Belt and W. J. Assel took part.

RENSSELAER POLYTECHNIC INSTITUTE

The Rensselaer Polytechnic Institute has elected the following officers for the new term: A. M. Greene, Jr., Honorary Chairman; W. D. Small, President, and A. E. Moore, Secretary.

STATE UNIVERSITY OF KENTUCKY

Alonzo G. Kenyon delivered a lecture at the November meeting of the State University of Kentucky Student Branch on Fuel Economy and the Method of Presenting these Ideas to Locomotive Engineers and Firemen. The lecture included the illustration of the chemistry of combustion and the properties of coal and firing by laboratory experiments and blackboard diagrams.

STEVENS INSTITUTE OF TECHNOLOGY

At a meeting of the Stevens Engineering Society, November 9, James Hartness dealt with the psychology of invention in his lecture, Some Non-Technical Phases of Machine Design. On November 16, A. W. MacNabb addressed the society, his subject being The Manufacture of the Edison Mazda Lamp. Mr. Callender of the Studebaker Corporation spoke on the Manufacture and Testing of Automobiles at the meeting of the society, November 23.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch held a meeting November 15, at which Walter Tangeman presented a paper on The Knight-Silent Engine.

UNIVERSITY OF ILLINOIS

The Student Branch of the University of Illinois held a meeting December 8, and J. M. Weff of the Mine Rescue Station gave a talk on the Draeger Oxygen Helmet, and five miners gave a demonstration of first aid to the injured.

UNIVERSITY OF KANSAS

At the November 9 meeting of the University of Kansas Student Branch Lawrence L. Brown read a paper on The Indiana Steel Company's Plant at Gary, Ind. The program also included reports on the following magazines: Horseless Age, Mr. Coggins; The Journal of The American Society of Mechanical Engineers, Mr. Tangeman; and Die Zeitschrift des Vereines deutscher Ingenieure, Mr. Van Houten.

At a meeting held December 7 the program was as follows: The Western Electric Company's Plant at Chicago, J. D. Howard; The Reinforced Concrete Arch across the Tiber River at Rome, L. Angevine; A New Material for Aeroplane Motors, Mr. Fairchild; The Task and Bonus System of Management, Mr. Wentling.

The student branch held its annual meeting December 14, at which the following papers were read: Drilling Gas Wells, Wm. M. Welch; Care of Gas Wells, H. R. Davis; Internal-Combustion Engines and Their Performance in Service, G. E. Hines; The Action of Reciprocating Pump Valves, Prof. C. I. Corp; Shop Management, B. W. Benedict; Relation of Technical School Engineers to the Practical Profession; Do Schools Pay? Louis Bendit. Prof. W. A. Whitaker gave a complete history of steel and iron manufacture from the Mesabi Range ore to the finished product, and illustrated his talk with lantern slides.

UNIVERSITY OF MISSOURI

At a meeting of the University of Missouri Student Branch, November 20, a paper on the Gas Power Plant Equipment by Ralph George and P. A. Tanner was read. On December 4 a lecture was delivered on the National-Acme Machine Company's multiple spindle screw-cutting machine, by O. L. Henn, demonstrator for the company.

WASHINGTON UNIVERSITY

Mr. Rossi presented a paper on Oil Fuel for Steam Boilers at a meeting of Washington University Student Branch, November 23. The uses, advantages, costs, etc., were fully discussed. A second paper was read by Mr. Berger on Advice to Engineering Graduates.

YALE UNIVERSITY

The Yale University Student Branch held a meeting on December 3, and Prof. Charles H. Benjamin, Dean of the Engineering Schools of Purdue University, gave an illustrated lecture on The Cost of Power. Charts were shown on which the prices of various manufacturers were compared.

MEETINGS OF THE COUNCIL

DECEMBER 5, 1911

A meeting of the Council was held on December 5, 1911, E. D. Meier, President, presiding. There were present: Chas. Whiting Baker, George M. Brill, Alex. C. Humphreys, Henry G. Stott, Irving E. Moultrop, James Hartness, H. G. Reist, Henry L. Gantt, Stanley G. Flagg, Jr., F. R. Hutton, F. W. Taylor, Jesse M. Smith and Calvin W. Rice, Secretary. Regrets were received from W. F. M. Goss.

Voted: That the reports of the Standing Committees be accepted and published in The Journal and Transactions.

Voted: That the Annual Report of the Council be accepted.

Voted: To amend the action of the Council by changing the words "student members" to "student affiliates" and the words "Sister National Engineering Societies" to "the American Society of Civil Engineers, the American Institute of Electrical Engineers and the American Institute of Mining Engineers."

The President reported with respect to an International Engineering Congress proposed for January 1915, that he had had a conference with the President-elect of the American Society of Civil Engineers, also Alfred P. Boller, Vice-President of the American Society of Civil Engineers, with Charles Kirchhoff, President of the American Institute of Mining Engineers, and with Gano Dunn, President of the American Institute of Electrical Engineers, and that they had expressed themselves in favor of such a congress, to be held in San Francisco in 1915.

The Secretary read a letter from T. W. Ransom, Secretary of the San Francisco Committee on Meetings, advising the Society of a meeting of the members resident in and about San Francisco at which a report was received from the chairman of the committee on an International Congress, and suggesting that the Society appoint three delegates to attend a preliminary meeting January 15, 1912, for the purpose of formulating plans, one of such delegates to be an executive officer of the Society.

Voted: That it was the sense of the Council that the Society favor preliminary consideration of the matter. The Secretary was instructed to represent the Society at the meeting called for the formulation of plans, January 15, 1912, with two other members of the Society, to be chosen by the President from the membership in and about San Francisco.

The Secretary was also instructed to see that all meeting places, halls, etc., be provided for free in the arrangements made by the Exposition.

Voted: That the action of the Council accepting the resignation from membership of E. M. Blake be rescinded.

The Secretary reported the following deaths: H. W. Bulkley, T. B. Davis, J. J. Ferrier, H. S. Morrison, Thos. F. Slater.

The New York Committee on Meetings presented nominations from the membership.

Henry G. Stott, appointed Honorary Vice-President to represent the Society at the hearings of the National Waterways Commission, made an informal report to the effect that he had appeared before the Commission as the representative of the Society and the American Institute of Electrical Engineers, and in behalf of the Electrical Engineers presented a brief. The Commission devoted a day and a half to the consideration of the presentation made by the representatives of the engineering societies, and at the conclusion publicly thanked them in recognition of the splendid coöperation rendered.

F. G. Tallman, a former member of the Council, was invited to present to the Council a plan covering a testimonial to Prof. John E. Sweet on his eightieth birthday.

Voted: That Ambrose Swasey, Past-President, be appointed chairman of a committee, with power to add to the Committee, to honor Professor Sweet on the occasion of his eightieth birthday, and that the personnel of the committee include members who attended the organization meetings of the Society from among Professor Sweet's boys.

The Committee appointed includes Ambrose Swasey, Chairman, Robert W. Hunt, Wm. Kent, E. D. Leavitt, C. B. Richards, F. G. Tallman, Worcester R. Warner and Wm. H. Wiley.

Voted: To extend the thanks of the Council to Past-President F. W. Taylor, Vice-Presidents C. W. Baker, A. C. Humphreys, W. F. M. Goss, and Managers H. L. Gantt, I. E. Moultrop and W. J. Sando, for their assistance and advice, and to record this expression of regret at the expiration of their term of office.

Voted: That the thanks of the Council be extended to the American Institute of Electrical Engineers for their courtesy in offering the use of the director's room for the meeting of the Council.

Voted: That the thanks of the Council be also conveyed to the American Institute of Mining Engineers, and to the National Electric Light Association for their kind offer of the use of the rooms of their respective societies during the Annual Meeting.

On motion adjourned to Friday, December 8.

DECEMBER 8, 1911

The Council met on Friday, December 8, at 2.30 p.m., and was called to order by E. D. Meier. Jesse M. Smith, Past-President, was appointed to introduce President-elect Alex. C. Humphreys, George M. Brill, Vice-President, to introduce Vice-President Ira N. Hollis, and James Hartness and H. G. Reist to introduce Managers Henry Hess and George A. Orrok.

James Hartness was appointed temporary Secretary and recorded the following minutes.

Voted: That Calvin W. Rice be reappointed Secretary of the Society on the same terms and conditions as last year.

Voted: That F. R. Hutton be reappointed Honorary Secretary on the same terms and conditions as last year.

At this point the Secretary, Calvin W. Rice, assumed his position and recorded the following minutes.

Voted: That Fred J. Miller be reappointed Trustee of the United Engineering Society to serve for a term of three years.

Voted: That F. R. Hutton be reappointed representative of the Society on the John Fritz Medal Board, to serve four years.

Voted: That the Council appoint an Executive Committee to consist of the President and five other members of the Council; that these five members be selected by letter ballot of the members of the Council; that the Secretary be authorized to send a blank ballot to each member of the Council, with a copy of this resolution and be authorized to receive and count the votes; that the ballots close at 12 o'clock noon on Thursday, December 28, 1911; that the five persons receiving the largest number of votes be declared elected and so notified by the Secretary.

Voted: That for the purpose of contemplated coöperation with engineering societies, it is suggested that the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, and The American Society of Mechanical Engineers appoint a Conference Committee, to consist of two members from each of these four national engineering societies the Conference Committee to hold informal meetings whenever anything may come up that seems of sufficient importance to receive the attention of all the societies, such Committee is to be entirely informal and without legislative power; the representatives of each society to refer matters back for authoritative action, when agreed in committee to be of sufficient importance.

Voted: That if in the opinion of the Conference Committee it is desirable to increase the number of societies represented in this Committee, such opinion be referred back for approval of the governing boards of the societies named in this resolution.

Voted: That the President appoint the representatives of this Society on such Conference Committee.

Voted: To extend to the Committee on Meetings the thanks and congratulations of the Council for all its work in connection with the Annual Meeting.

Understanding that the members have reported in favor of reappointment of the Committee that served last year as a Committee on Meetings in New York, it was

Voted: To approve such Committee, to consist of F. H. Colvin, Walter Rautenstrauch, Edw. Van Winkle, R. V. Wright, F. A. Waldron.

Resolved: That a vote of thanks be extended to the Committee on Meetings in New York for the admirable way in which they carried out the part of the Annual Meeting of which they were in charge.

Voted: That the Committee on Constitution and By-Laws be requested to consider and report to the Council tentative forms of By-Laws to cover the topics referred to in the proposed amendment to the Constitution as discussed and presented at the Annual Meeting just adjourned.

Voted: To approve the action of the Chairman of the Committee on Constitution and By-Laws at the Wednesday morning session of the Annual Meeting, in changing the words "provided for" to "arranged" as given in the directions of the Council at its meeting of November 20, 1911, and that the minutes of such meeting be so amended.

Voted: To approve the minutes, as amended, of the meeting of the Council, December 5.

Voted: That it is the sense of the Council that regular meetings of Council be held each month, October to May inclusive, at a definite date and hour to be determined later.

On motion meeting adjourned subject to call of the Chair.

THE NEWLY ELECTED OFFICERS FOR 1912

ALEXANDER CROMBIE HUMPHREYS

President Am. Soc. M. E.

Alexander Crombie Humphreys, second president of Stevens Institute of Technology, was born in Edinburgh, Scotland, March 30, 1851. He came to this country at the age of eight and was educated in his father's private school, Boston, Mass. When fourteen years old he passed a preliminary test examination for the United States Naval Academy, but was disqualified on account of his youth. He then entered a Boston insurance office. In 1866 he removed to New York, where he secured employment with the New York Guaranty & Indemnity Company, and in a few years was made receiving teller and assistant bookeeper. In 1872 he became secretary-treasurer, and shortly afterwards superintendent of the Bayonne & Greenville Gas Light Company. For years he had spent much of his spare time working with tools, and he now came in touch with mechanical undertakings as secretary of the building committee of his company. Upon the completion of the plant he was offered the position of secretary and treasurer. Three years later he recognized his need of a technical course at Stevens Institute, and presented himself at recitations and lectures two mornings of each week, doing the prescribed work of the institute at home. During the next four years he kept up with his class, attended to his business duties and supported his wife and two children. In 1881 the president and the faculty of the institute passed a formal resolution congratulating him upon his success under these exceptional conditions. Shortly after his graduation he accepted the office of chief engineer of the Pintsch Lighting Company, for which he built many oil-gas works, conducted experimental work on a large scale, and perfected an organization for carrying on the business. In January 1885, he became superintendent of construction of the United Gas Improvement Company of Philadelphia, and within a few months was its general superintendent and chief engineer. Under a uniform system of management and control developed by him, many properties were operated from Philadelphia. Early in 1892, in association with Arthur G. Glasgow, he established the London firm of Humphreys & Glasgow, consulting gas engineers, which was successful from the start. This firm designed and constructed the carbureted water gas plant. Other works constructed by Humphreys & Glasgow are now in operation in all parts of the world except North America. Here Mr. Humphreys built many plants as chief engineer of the United Gas Improvement Company. Upon his resignation from the United Gas Improvement Company, two years later, he formed the New York firm of Humphreys & Glasgow, which has been equally prominent in the American field. The specialty of gas engineering presents technical difficulties that few people appreciate, but since entering the field of consultant practice Mr. Humphreys has achieved a reputation far beyond the confines of this branch. When the presidency of Stevens Institute was rendered vacant by the death of Henry Morton, the faculty unanimously petitioned the Board of Trustees to elect Mr. Humphreys, and this action was seconded by many of the alumni individually, who urged his appointment as a man of broad sympathies, an able administrator, and a thorough man of affairs. He was elected June 5, 1902. As president of this great school of practical knowledge he is doing more good than can be readily measured; his outspoken criticisms of technical education, as viewed in some quarters, have already caused a profound conviction of the need of more thoroughness and less display. The University of Pennsylvania has since conferred upon Mr. Humphreys the honorary degree of Sc.D., and the honorary degree of LL.D. has been conferred upon him by Columbia University, New York University and Princeton University.

In 1907 Mr. Humphreys succeeded Bayard Dod as president of the Board of Trustees of Stevens Institute. He is now president of the Buffalo Gas Company. He is a member of the American Institute of Mining Engineers, of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the Institution of Civil Engineers, the British Association for the Advancement of Science, and the American Association for the Advancement of Science; past-president of the American Gas Light Association and of the American Gas Institute; president of the Engineers' Club of New York, the Robert Burns Society, New York, the Canadian Society, New York; a member of the National Society for the Promotion of Industrial Education, of the National Society for the Promotion of Engineering Education, and of the Union League, Century, Lawyers' and Chemists' Clubs of New York; vice-president of St. Andrew's Society, New York; a member of the University Club, Philadelphia, and many other societies working in public interest; a member of the Chamber of Commerce, New York, and president of Humphreys & Miller, Inc., New York, successors to Humphreys & Glasgow.

VICE-PRESIDENTS

WILLIAM FREDERICK DURAND

William Frederick Durand was born in Beacon Falls, Conn., March 5, 1859, and lived as a boy on a New England farm in Derby, Conn. He was educated in district and high schools, and in 1876 entered the United States Naval Academy in the then recently organized engineering course. He was graduated in 1880 and remained in the naval service as cadet and assistant engineer until 1887. From 1883 to 1885, under the practice then prevailing, he was detailed as instructor in engineering subjects in Lafayette College, Easton, Pa. In 1887 he resigned from the naval service to accept an appointment as professor of mechanical engineering in the State Agricultural College of Michigan, leaving there in 1891 to take the professorship of marine engineering in the newly organized School of Marine Engineering and Naval Architecture in Sibley College, Cornell University, under the general charge of the late Prof. R. H. Thurston. In 1904 he resigned this position and was appointed professor of mechanical engineering in the Leland Stanford Jr. University, which position he still holds.

His later services in the navy were in connection with the design, construction and sea trials of the earliest steel ships of the so-called "New Navy," begun in 1883. His work at Cornell University was largely in the marine field, and he is the author of numerous papers and articles dealing with the problems of marine construction. During this period he also published two books, Resistance and Propulsion of Ships, and Practical Marine Engineering. Since taking up his work in California his professional connections, aside from teaching, have lain largely in the fields of steam and hydraulic power plant engineering, on which he has written numerous articles and papers.

Immediately after the earthquake of 1906, which wrecked in greater or less degree most of the buildings of the university, Professor Durand was partially relieved of his teaching duties and served for about two years and a half as a member of a commission of engineers composed of three members of the engineering faculty, charged with the executive direction of the work of restoring and rebuilding such of the buildings as were required for immediate purposes.

He has since December 1909, served as a member of a consulting board of engineers for the power bureau of the Los Angeles aqueduct, and has taken an active part in the preparation of plans for the development of hydroelectric power in connection with that enterprise.

IRA NELSON HOLLIS

Ira Nelson Hollis, professor of engineering at Harvard University, was born in Mooresville, Ind., March 7, 1856, and was educated in the public schools of Louisville, Ky. He was appointed cadet engineer at the Naval Academy in 1874 and was graduated in 1878. He was commissioned assistant engineer in the Navy in 1880, passed assistant engineer in 1888, and resigned in 1893, having been appointed to his present position at Harvard. During the fifteen years after graduation from the Naval Academy, he served in various positions connected with the design, inspection and operation of marine machinery, and was chief engineer of two ships.

Professor Hollis has published articles on naval, educational and engineering subjects, and is a member of the following societies: American Academy of Arts and Sciences, United States Naval Engineers, American Society of Naval Architects and Marine Engineers, Boston Society of Civil Engineers, Society for the Promotion of Engineering Education, and Massachusetts Military Historical Association.

THOMAS B. STEARNS

Thomas B. Stearns was born October 3, 1859, in Brooklyn, N. Y., and was educated in the public schools of that city, and at the Brooklyn Collegiate and Polytechnic Institute. He received his engineering training at the Columbia School of Mines, from which he was graduated in 1881, with the degree of E.M. After a number of years spent in examining mines in the western part of the United States and in Mexico, and in studying the milling and smelting processes, ore treatment, and the machinery used in ore handling, he opened an office in Denver in 1885 as a consulting and contracting engineer. The following year he formed a partnership, known as Stearns, Roger & Company, which was merged in 1881 into the Stearns-Roger Manufacturing Company, of which Mr. Stearns is now president.

Mr. Stearns has designed, supervised or constructed a number of important installations, notably central station power and lighting plants, and mills for the chlorination of ores in different centers, and has been largely instrumental in developing the chlorination process as it is now applied, devising new machinery and methods of application for roasting and for chlorination. He has specialized in the treatment of ores of the precious metals, and has built and applied various devices for the mining of minerals, for air compressor and drilling work, hoisting, sorting and handling on the surface, and for concentrating, cyaniding, smelting and milling ores. Since the growth of the beet sugar industry in the West he has studied the refining process and built sugar machinery. The sugar house at Garden City, Kansas, was built by him as well as designed with his assistance.

Mr. Stearns is a member of the American Institute of Mining Engineers, the Colorado Scientific Society, and the American Association for the Advancement of Science, a past-president of the Denver Club and of the University Club of Denver, and a member of the Denver Athletic Club, the Denver Country Club, the University Club of New York and the Automobile Club of America. He is president of the Gilpin County Light, Heat & Power Company, the Arkansas Valley Electric Company, the Brush Light & Power Company, the Hinsdale Power & Development Company, director in the Grand Junction & River Valley Railway Company, and vice-president of the Mountain Electric Company and the Columbia National Life Insurance Company.

MANAGERS

CHARLES JACKSON DAVIDSON

Charles Jackson Davidson was born in Lanesboro, Minn., on July 6, 1867, and received his education in the public schools. At the age of eighteen he apprenticed himself to Hubbard & Gere, machinists and steam-fitters, in Sioux City, Ia., and during his three years of service gained practical experience in engineering. In 1888 he entered the employ of the R. D. Fowler Packing Company at Sioux City, taking charge of the boiler room. After several years he was promoted to the position of chief engineer and continued in this capacity until 1893, when he resigned to take up similar work with the Sioux City Traction Company. Six years later he removed to Milwaukee to become chief engineer of power plants for The Milwaukee Electric Railway and Street Company, having charge of drafting room and power plant design and superintending the lighting of city and suburban railways and steam heating. During this time Mr. Davidson also acted as consulting engineer for the Union Electric Light and Power Company of St. Louis.

A few months ago Mr. Davidson opened an office of his own in Chicago, under the firm name of Woodmansee, Davidson & Sessions, having resigned his work with the Milwaukee Electric Railway and Street Company in order to do so, and is now engaged in private practice.

HENRY HESS

Henry Hess was born January 10, 1863, at Darmstadt, Germany, and was educated in the German-American Institute, New York City, and at a German high school. Mr. Hess preferred technical pursuits to his father's profession of sculpture and worked in various machine shops to gain the necessary training, being successively journeyman, foreman, superintendent, draftsman and designer. By changing frequently into as diverse lines as possible he covered a wide field, out of which he gradually decided upon machine tool design as his specialty. A five year stay in connection with the building and operation of the German Niles Tool Works Company near Berlin, first as consulting engineer and later as managing director, were productive of familiarity with European machine building conditions. He returned to the United States after having acquired the American ball-bearing patents of the German Small Arms and Manufacturing Company, and became the pioneer of modern ball-bearing development in this country.

Mr. Hess has contributed articles on technical subjects at various times to the American Machinist, Machinery, the Engineering Magazine, etc., and to various professional organizations. He is a past-president of the Society of Automobile Engineers, a president of the Engineers Club of Philadelphia, and a member of the American Electro-Chemical Society of Great Britain, the German Institute of Automobile Engineers, Verein deutscher Ingenieure, Schiffbautechnische Gessellschaft, and Verein fur Eisenbahnkunde. He is president of the Hess-Bright Manufacturing Company and of the Hess Steel Castings Company. During the St. Louis Exposition he served as a member of the jury.

GEORGE A. ORROK

George A. Orrok was born in Dorchester, Mass., on July 3, 1867, and received his education at the Mather School in that city and at the School of Mechanic Arts. He entered the Massachusetts Institute of Technology in 1885, but was obliged to give up his college course in his junior year on account of serious eye trouble. He spent some time investigating mining property in the South and in surveying in Wisconsin, and from 1888 to 1892 engaged in teaching in Bridgewater, West Springfield and Easthampton, Mass., at the Ogden Military Academy in Ogden, Utah., and the Agricultural College at Logan, Utah. In 1892 he entered the employ of F. S. Pearson as draftsman and was engaged in the design of the West End Street Railway, the Dominion Coal Company, the Metropolitan Light Railway Company, the Brooklyn Heights Railway Company, etc.

In 1898 he was employed by the New York Edison Company as draftsman, becoming chief of the department in the same year, and mechanical engineer in 1906, which position he still holds. Mr. Orrok is also assistant engineer to Thomas E. Murray, consulting engineer, and in this capacity has had charge of the design and construction of power houses for a number of railroads and electric lighting companies, including the large hydroelectric development at Chattanooga, Tenn.

He is a member of the American Society of Civil Engineers, the American Institute of Mining Engineers, the Society of Naval Architects and Marine Engineers, a past-president of the Brooklyn Engineers Club, and a member of the Technology Club of New York.

ANNUAL REPORTS OF STANDING COMMITTEES

REPORT OF THE HOUSE COMMITTEE

The decorating and furnishings, completed last year, have proven so adequate and satisfactory that the House Committee refrains from recommending any considerable additional expenditure at present. Summer coverings for furniture, inner curtains and some minor furnishings should be provided for in future appropriations. An authorization, as yet unexpended, covers the work now in progress of securing and hanging the portraits of the Honorary Members.

In this connection, the Committee wishes to acknowledge its appreciation of the painstaking work which the Sub-Committee Chairman, Mr. Van Winkle, has done during the past year for the Society, such work including the collection of the pictures of Past-Presidents and Honorary Members, and a valuable index of important Society relics.

It is the earnest hope of the Committee that the improvements effected will encourage the greater use of the rooms and facilities of the Society by its members.

Respectfully submitted,

F. Blossom, *Chairman*
B. V. Swenson
E. Van Winkle
H. R. Cobleigh
S. D. Collett
House Committee

REPORT OF THE LIBRARY COMMITTEE

As the library work has developed at the monthly meetings of your Committee, a sense of its responsibility, not only to the Society but to the entire body of practicing engineers, has steadily increased. In no engineering center are so many great patent litigations originated and conducted as in New York, and not only are the records of most recent engineering progress constantly required, but also the history of the art up to the present moment.

The libraries of the Bar Association and of the Academy of Medicine are examples of what has been achieved by other professions.

Your Committee has carefully considered means for the establishment of an organization for library government, and of principles of selection of technical literature, which will develop the present library with symmetry along the lines of engineering science, with stated policies regarding the value of its accessions, in order to secure for it the position among technical libraries which only years of intelligently fostered growth make possible. Your Committee has especially encouraged the use of the library by members of the many organizations having headquarters in the Engineering Societies Building, and these have signified their desire to coöperate in its upbuilding.

Your Committee is gratified at the completion of the handsome gallery in the present main library room, in accordance with the plans of the Joint Library Conference Committee made at the time of the erection of the present building, but delayed by want of funds. By means of this gallery about 10,000 more volumes are made available in the main library reading room.

In connection with the library committees of the two other founder societies, your Committee heartily concurs in the appointment of William Parker Cutter, B. S. Cornell, to the important office of chief librarian. Mr. Cutter has attained distinction as librarian of Forbes Library at Northampton, Mass., and our library has already shown marked improvement under his intelligent administration.

The following library statistics are furnished by the librarian:

October 1, 1910, to September 30, 1911

Accessions	
Purchase	147
Gifts and exchanges	421
Total	568
Cards added to catalogue	12,158
Volumes bound	228
Cost	$252.24 (Average cost $1.10+)
Attendance	
Day	8,021
Night	2,947
Total	10,968

The library has for the past year put its facilities still more within reach of the membership living at a distance through the further development of technical searches. Lists of references have been compiled by request upon the following subjects, among many which might be named: steel belts; combustion of coal dust; efficiency tests of pumps for water works; ball and roller bearings; making of brass tubes; care of belting; size of drums for wire rope; design of hooks for cranes; automatic stops; fire hose pressure; high-speed tools; drying lumber in kilns; permanent molds; manufacture and properties of phosphor bronze; comparative value of various methods of power transmission; engineering standards and specifications; smoke abatement; composition and heat treatment of steel; steam meters; high pressure turbo-compressors; tap drills for various metals; manufacture of seamless steel tubes; shop costs. In some instances typewritten copies of articles have been furnished as well.

This is an especially valuable side of the work being done by the library and ought to appeal to all members who lack the time or opportunity to visit it to make such searches for themselves. Unless the work is extensive no charge is made and the cost of copying, translation or other service is gaged by the time required, and is slight in proportion to its value. Members are invited to make use of the library in this way.

A bookplate has been adopted by the Committee and will be placed in those books owned by the Society. It bears the seal of the Society above an open volume and also the words, "Ex libris American Society of Mechanical Engineers."

The introduction card which is now issued annually by the Society has been made to combine the features of the member's card for the library, which it was formerly necessary to issue separately on application of a member desiring to consult the files. The new card also has printed on its back the names of societies with whom library privileges are exchanged.

There is under consideration by the Publication Committee a more complete cross-referencing of the entire set of Transactions of the Society, which will add materially to the facilities for consulting papers and subjects treated in Transactions.

There has been received by gift from Professor Unwin, Honorary Member of the Society, the proposals for the first Niagara Falls Power Plant, also a large number of books which have been regularly announced in the successive issues of The Journal under Accessions to the Library. Your Committee also wishes to acknowledge with thanks the receipt of a number of pamphlets, a list of which is now on file in the Secretary's office.

Respectfully submitted,

L. Waldo, *Chairman*
W. M. McFarland
C. L. Clarke
A. Noble
E. G. Spilsbury
Library Committee

REPORT OF THE COMMITTEE ON MEETINGS

During the year, 24 local meetings have been held in addition to the Annual Meeting in New York and the Spring Meeting at Pittsburgh. Of this number 7 were held in New York and Boston, 3 in St. Louis and San Francisco, 3 in Philadelphia, and 1 in New Haven. It is expected to hold meetings in all of these cities during the coming year.

A meeting was also held in May with the Providence Society of Mechanical Engineers, on the new basis of affiliation adopted at the December 1910 meeting of the Council. In accordance with this basis of affiliation, any engineering society which is by its constitution, by-laws and practice in accord with the traditions and aims of the Society, may join with the Society in holding coöperative meetings, the affiliated society maintaining its own independence but having the privilege of reduced subscription rates to the Society's publications and of any printing reductions which the Society may secure. Similar meetings with the Providence society and probably with other organizations will be held from time to time.

Recognizing the necessities of the situation and that, in the holding of meetings by the members in the several parts of the United States, it is impracticable always to have papers formally prepared and forwarded to the central Committee on Meetings for scrutiny before presentation, and furthermore, that such a plan imposes great burdens on the central Committee, the Council has relieved the Committee on Meetings of the necessity of reviewing any papers except those to be presented at the general meetings of the Society, so that the Committee thus resumes its original functions of supervision of the Annual and Semi-Annual Meetings only. This has resulted in a greater sense of responsibility on the part of the Committees on Meetings in the several cities and also a feeling of greater freedom.

The Committee on Meetings has inaugurated, with the hearty approval of the Council, the development of sub-committees for the several branches of engineering. It will be the policy of the Committee to secure through these sub-committees an annual report on the state of the art, thus rounding out the field of activity of the Society, these reports being accompanied by special papers where possible, to be presented at the general meetings of the Society. The members of the Society have been asked, through circulars recently issued, to assist the Committee in this plan by making suggestions of experts who shall be invited to compose these committees without regard to relationship with the Society.

Three committees have already been formed and are doing excellent work. One upon Cement Manufacture held a most successful session at the Spring Meeting at Pittsburgh and has plans under way for another meeting. Two other committees, one on the Manufacture of Textiles and another on Machine Shop Practice, have arranged for a session at the Annual Meeting.

Respectfully submitted,

L. R. Pomeroy, *Chairman*
C. E. Lucke
H. deB. Parsons
W. E. Hall
C. J. H. Woodbury

Committee on Meetings

REPORT OF THE COMMITTEE ON MEMBERSHIP

During the fiscal year, October 1, 1910 to September 30, 1911, the Committee on Membership has held five meetings, at which a total of 401 applications for membership have been considered with the following results:

Withdrawn for various causes	7
Deferred indefinitely	6
Recommended for membership	368

Of the 368 names recommended for ballot, 327 were new candidates and 41 were candidates for promotion. The candidates recommended were voted for on two ballots submitted to the membership as follows:

Spring Ballot	161
Fall Ballot	205

The names of candidates elected to membership during the year appear in the Annual Report of the Council.

Respectfully submitted,

Francis H. Stillman, *Chairman*
George J. Foran
Hosea Webster
Theo. Stebbins
Wm. H. Boehm

Committee on Membership

REPORT OF THE PUBLICATION COMMITTEE

The Committee has proceeded during the current year on the lines laid down in the report as submitted to the Council at the beginning of the year. Volume 32 of Transactions recently issued contains in addition to the proceedings of the usual meetings a report of the meeting in England. To have published in addition all of the matter presented at the meetings of the year, would have necessitated the issuing of a two-volume edition of Transactions, for which there were not sufficient funds. Instead, a single volume of 1500 pages was published and 16 papers with discussions upon them were omitted.

As outlined in the last annual report, the efforts of the Committee have for several years past been in the direction of making The Journal self-supporting, and although the Committee did not state that this result would be accomplished this year, it did so hope and it now has the satisfaction to report that it has been accomplished as shown in the sub-joined table:

RECEIPTS

	1907–1908	1908–1909	1909–1910	1910–1911
Advertising	......	$12,000	$24.000	$31,000

EXPENSES

Journal Text	$8400	$13,100	$18,500	$16,000
Journal Advertising	....	7,000	11.800	15,000
	$8400	$20,100	$30,300	$31,000

During the past year The Journal has been self-supporting.

It is proposed to develop the condensed catalogue feature of the advertising section, as this form of advertising is believed to be of greater practical value than ordinary display advertisements and entirely in keeping with the character of The Journal. The plan is to make these pages as valuable as possible by incorporating engineering data and it is anticipated that a sufficient number of firms will become interested so that various classes of mechanical equipment will be fully represented in succeeding issues of The Journal.

The Committee has had in mind for a long time the plan of incorporating in the reading pages of The Journal a review of articles appearing in foreign periodicals to be published in the form of a topical index, supplemented by abstracts of some of the more important ones, the object being to place before members of the Society, although in condensed form, records of advances in engineering throughout the world not covered by our Transactions. The Committee has felt that until The Journal was self-supporting it could not recommend to the Council that it should branch out into new lines made necessary by the employment of a technical reviewer, but it feels now that it is in a position to make this recommendation which will still further add to the value of The Journal and which ought to increase its circulation among non-members, tending gradually to draw them into membership. Such a technical reviewer would be in a position to furnish translations of articles in foreign periodicals for the membership of the Society.

Through action by the Council the subscription price of The Journal has been reduced, making the price to the public 35 cents a copy or $3 a year, and to members 25 cents a copy or $2 a year, to be included in the dues as heretofore. This will make possible a wider distribution of the papers and discussions given at the meetings of the Society, thus adding to its prestige and benefiting the profession as a whole.

Last year the Committee brought to the attention of the Council, the need of indexing the Transactions of the Society from their beginning. It was understood from the Chairman of the Library Committee that certain indexing of other Transactions was contemplated and the Publication Committee has waited to learn what the work would be in order that a recommendation might be made. The Publication Committee desires to bring again to the attention of the Council the great need for a complete index to the volumes of Transactions.

Respectfully submitted,

H. F. J. Porter, *Chairman*
F. R. Low
G. I. Rockwood
G. M. Basford
C. I. Earll

Publication Committee

REPORT OF THE PUBLIC RELATIONS COMMITTEE

One of the most important subjects which has interested the Society and engineers generally, is the bill proposed before the legislature of one of the States, pertaining to the licensing of engineers. The Committee reported to the Council its opinion that it was impractical and inadvisable to pass any laws to license the profession of engineering and the Council in accepting this report instructed the Committee to coöperate with any other engineering society or with any individual engineers in opposing such laws.

E. D. Meier, President, and Calvin W. Rice, Secretary, attended a meeting of engineers on February 16, 1911, to consider the subject of laws for licensing engineers. Members of the American Society of Civil Engineers, the American Institute of Electrical Engineers, and the American Institute of Mining Engineers were present at the meeting and unanimously adopted the following resolution:

> Whereas, the engineering profession is threatened with the passage of a Licensing Bill at Albany by the New York State Legislature, and
>
> Whereas, the legislation proposed by the bills now in committee will operate to the serious disadvantage of our profession and the business interests of the State;
>
> Now, therefore, be it resolved, That it is the unanimous opinion of the undersigned that it is to the interest of the engineering profession and the public that no license bill whatever be passed and that the presidents of the engineering societies be requested to appear in person, or by representative, at Albany at any of the hearings before the legislative committee which has the matter in charge, and vigorously oppose the passage of any bill for licensing engineers; and also that the various representatives of the societies, as above, shall get together to insure coöperative action.

Cary T. Hutchinson
William Barclay Parsons
Allen Hazen
W. J. Wilgus
A. A. Stuart
Ralph Chambers
Henry W. Hodge
Calvin W. Rice
Charles Whiting Baker
Alfred P. Boller
L. B. Stillwell
S. L. F. Deyo
Rudolph Hering
Ralph D. Mershon
H. de B. Parsons
Samuel Whinery
A. W. K. Billings
George B. Francis
Frank J. Sprague
E. D. Meier
R. S. Buck

These resolutions were printed and distributed among the engineers of New York State.

On March 1, the Hoff Bill was considered by the Committee of the Assembly on General Laws. The bill was opposed in short speeches of five minutes each by E. D. Meier, President Am.Soc.M.E., A. P. Boller, R. S. Buck, E. G. Spilsbury, Mem.Am.Soc.M.E., G. B. Francis, F. J. Sprague, and P. C. Ricketts, Mem.Am.Soc.M.E., who spoke against any and all bills; and by Judge Danneher, retained by the Technical League of America, who opposed only the Hoff Bill and announced his intention of favoring the McGrath Bill. Mr.

Tillson, representing the Brooklyn Society of Municipal Engineers, was the only one in favor of the Hoff Bill.

On March 14, a special committee again appeared before the Committee on Public Education to consider the McGrath Bill. Mr. Elliot, President of the Technical League of America, and Judge Danneher, counsel for the League, spoke in favor of the bill but offered to cut out each item to which the speakers raised objection. The principal speakers against the bill were Mr. Merritt, minority leader in the House, James M. Dodge, Chairman of the Committee on Public Relations of the Society, Dean R. C. Ricketts, Mem.Am.Soc.M.E., representing Cornell, Rensselaer and Syracuse Universities, Alfred P. Boller, Col. E. D. Meier, President Am.Soc.M.E., E. G. Spilsbury, Mem.Am.Soc.M.E., and Frank J. Sprague. A resolution passed by the Engineering Society of Eastern New York, against any and all engineers' license bills, was presented by their secretary.

A special committee of engineers appointed by the General Committee, consisting of Col. E. D. Meier, President Am.Soc.M.E., Chairman, Alfred P. Boller, R. S. Buck, C. W. Baker, Mem.Am.Soc.M.E., George B. Francis, E. G. Spilsbury, Mem.Am.Soc.M.E., and Frank J. Sprague, is now collecting information in regard to the Hoff Bill, with a view to bring pressure to bear to defeat it. The principal danger in laws of this kind lies in the fact that if New York passes such a bill, many, if not all, of the other States will follow, and this will prove a tremendous burden on all engineers who have occasion to do professional work in different States, as reciprocity between them all will be difficult to obtain. It is proposed that when the question has been settled in New York State, the main arguments evolved in the discussion shall be printed and sent to the membership of the national societies, with the suggestion that they use these facts in opposing similar bills hampering the profession in their States.

The Legal Aid Society asked the coöperation of this Society in furnishing technical advisers and the Council was pleased to respond that such nominations would be made when requested.

Calvin Tomkins, Commissioner of Docks, invited the Society to appoint a committee to coöperate with the city in the solution of the problem of handling freight at terminals. The Council did not find itself in a position to undertake such duties for the present, but Commissioner Tomkins was invited to present a paper before the Society at one of its local meetings.

Another matter considered was the invitation of the Mexican

Government asking the assistance of the Society in placing graduates in engineering positions. The Council most cordially responded, expressing willingness to give publicity to such a request by an announcement in The Journal of the availability of such graduates.

James M. Dodge, Chairman of the Committee, elected for a term of five years, has been obliged to withdraw on account of the many demands upon his time; he will, however, continue to serve on the Committee.

Respectfully submitted,
J. M. Dodge, *Chairman*
R. W. Hunt
D. C. Jackson
J. W. Lieb, Jr.
F. J. Miller
Public Relations Committee

REPORT OF THE RESEARCH COMMITTEE

The activities of the Research Committee during the past year are not entirely revealed by the tangible results which have been accomplished. All that has been done must be regarded as preliminary to actual work.

The Secretary's office, under the direction of the Committee, has improved and extended its directory of the men who, as mechanical engineers, are engaged in work of scientific research in this country. There is also a directory of the laboratories in which these men are working. In the process of perfecting this record, an inquiry was made of 88 technical schools and universities, 63 of which number have reported. The list includes 5 physical laboratories, 15 chemical laboratories, 5 metallurgical laboratories, 33 electrical laboratories, 1 laboratory for the study of illumination and 54 dealing with problems of interest to the Committee. Of these 54 laboratories, 47 are especially equipped for steam engineering, 44 for gas engines, 33 for hydraulics, 26 for testing materials, 21 for refrigeration, and 6 for fuels. A small number are prepared for work in compressed air, for a study of oils, for sugar-house engineering, for the testing of road materials, for railway engineering, and for heating and ventilating. This information constitutes a permanent record in the file of the office of the Secretary and is available to all members.

There have been two formal meetings of the Committee, one in New York on December 6, 1910, and the other in Pittsburgh on June 1, 1911.

One of the results of the December meeting was a decision on the part of the Committee to ask authority of the Council to appoint sub-committees, which authority was duly given.

At the June meeting some progress was made in the development of plans for the sub-committees. The present status of this matter is as follows:

A Sub-Committee on Safety-Valve Investigation, which is to deal with the whole question involving the action and the efficiency of safety-valves, is in process of formation under the chairmanship of R. C. Carpenter, a member of the Research Committee. The personnel of this sub-committee cannot at this time be reported.

It has been proposed to have a Sub-Committee on Researches in Mechanical Properties of Materials Used in Electrical Engineering, and R. D. Mershon, a member of the Research Committee, has been asked to act as Chairman.

The advisability of having a Sub-Committee on Fuel Utilization was considered, and it was voted that the Gas Power Section be advised that the Research Committee will depend upon it to cover this field. The Gas Power Section has been so advised.

It was agreed that there should be a Sub-Committee on Pneumatics and Aeronautics, but such a sub-committee has not yet been formed.

Your Committee desires in this connection to give some expression of the service performed as a member of the Committee by James Christie, whose death has occurred during the past year. Mr. Christie was among those who were faithful in attending Committee meetings and who gave to the deliberations of the Committee his best attention. His successor upon the Committee has not yet been appointed.

There has been formed a Sub-Committee on Steam Devices, the personnel of which is as follows: R. H. Rice, Member of the General Research Committee, Chairman; C. J. Bacon; E. J. Berg; W. D. Ennis; L. S. Marks; Max Patitz. They report concerning the present state of knowledge of the laws governing the transmission of heat through metallic tubes from gases and liquids to gases and liquids, that it is now rather definitely established that in the general case, the heat transfer takes place in at least three separate operations:

a The transfer from the warmer fluid to the initial surface of the tube.

b The heat passage through the tube wall from the warmer surface to the cooler surface of the tube.

- *c* The transfer from the secondary tube wall to the cooler fluid.

This has been expressed by the general equation of Peclet

$$\frac{1}{k}=\frac{1}{c}+\frac{1}{q}+\frac{1}{r}$$

where

- k = the coefficient of heat transmission.
- q depends on the thermal conductivity of the tube which is known quite accurately and equals $\frac{K_t}{D}$ where D = thickness of tube; K_t = a constant depending on the material of which the tube is made.
- r (following Osborne Reynolds) = $\frac{d_w v_w}{B}$; or (following Josse) = $510\sqrt{V_w}$; where d_w = density of the cooling fluid, V_w = velocity of cooling fluid, and B = a constant.
- c (following Pickworth and Nickolson) = $1.2V_s+29400d_s-306$, an empirical formula where V_s = velocity of the hotter fluid and d_s = its density.

As compared with c or r, q is always so large that in practical problems it can be neglected; in other words, the heat-transferring capacity of metallic tubes is always largely in excess of the heat which is brought in contact with the tube surface. For this reason, it is much more convenient to use a simpler expression, such as $K=C\sqrt{V_w}$.

Fourier stated the law as follows:

$$dH=KSdz(T-t)$$

where S = surface, z = time, and T and t = temperature. When S and Z are unity, this expression becomes $H=K(T-t)$ and $(T-t)$ corresponds to θm in our modern expression. $H=N$, the total heat transferred and $K\theta=C\sqrt{V_w}\theta$ which is the form commonly used today.

There are many practical problems connected with the determination of the laws of heat transfer. Some of the more important are:

- *a* The transfer from flue gas under the conditions existing in economizers. Here the transfer is of the order of 2 B.t.u. per sq. ft. per hr. per deg. difference of temperature.

b The transfer from flue gas to boiling water under boiler conditions (feedwater heated to steam temperature). Here the transfer is of the order of 10 B.t.u. per sq. ft. per hr. per deg. difference of temperature.

c The transfer from flue gases to steam or air under superheater or air heater conditions. This transfer is of the order of 4 B.t.u. per sq. ft. per hr. per deg. difference of temperature.

d The transfer from hot air to colder water under air cooler conditions. This is of the order of 4 B.t.u. per sq. ft. per hr. per deg. difference of temperature.

e The transfer from condensing steam to water under surface condensing conditions. This is of the order of 1500 B.t.u. per sq. ft. per hr. per deg. difference of temperature, when no air is present, but falls off to 500 to 600 B.t.u. when an ordinary amount of air is present.

There seems to be an essential difference in the action when a condensible gas or vapor is the high temperature fluid. Here the vapor gives up its latent heat to the colder tube and contracts enormously in condensing, causing an exceedingly rapid flow normal to the tube. It may be that an analogous action takes place when the colder tube is exposed to the "bombardment" of radiant heat, as in the case of boiler tubes exposed to the rays from white hot surfaces or fuel or brickwork. Professor Bone in his lecture before the Royal Society last year stated that he had obtained in an experimental boiler an evaporation as high as 41 lb. of water per sq. ft. of surface, which corresponds to approximately 25 B.t.u. per sq. ft. per hr. per deg. difference. This was due to the radiant heat condition. Probably the best exposition of the problem where a permanent gas is the hotter fluid is given in Professor Dalby's report to the Institution of Mechanical Engineers, October 29, 1909, and his conclusions summed up on pages 25 to 28 show the exceedingly difficult nature of the problem and the necessarily costly means which must be used for its complete solution. The main factor is the determination of the temperature gradients in all parts of the boiler. That this is also true of the condenser conditions may be seen from the work of Smith and Josse and the paper read by Mr. Orrok before the Society last year.

The "mass flow" theory of Osborne Reynolds and Jordan seems to be another form of stating the fact that where more heat is present more is transmitted, and it is known that this is true up to the limit of heat transfer. Kreisinger and Ray have investigated this problem, with an experimental boiler using air heated electrically as the hotter fluid, and their results have been widely quoted. The work of Perry developed by Breckenridge in Bulletin 325 of the Geological Survey is also of great value in this connection.

Summarizing, the lines of work which will be most fruitful are as follows:

a A final determination of the radiant heat law (Stefan's law) with a separation from conduction and convection problems. It is probable that Stefan's law is nearly correct, but does the black body condition exist, and between what ranges of temperature? Bone's experiments seem to show that it may exist at temperatures below red heat. (See Bulletin No. 8, Department of Mines.)

It is known that in boiler conditions radiation is much more efficient than either conduction or convection. How much of the heat study can be developed as radiant energy? Both Nicholson and Bone claim that the boiler of the future will depend largely on radiation rather than conduction.

b More study of the phenomena of heat transfer in the absence of radiant energy (if this is possible). What is the effect of dust and soot in the gases? Do the dust particles act as black bodies and give out radiant energy? It has been stated that 98 per cent of the temperature drop took place in the passage of the heat from the gas to the tube surface. Is this statement correct, and if so, can the "gas film" be removed or made a better conductor?

c Determination of the temperature gradient under a variety of practical conditions, and with full size apparatus. Does the gas film give more trouble when inside a fire tube with axial flow of gases or when outside a water tube with a flow across the surface.

d A determination of the law of temperature rise in the water flowing in a condenser tube. The tube should be long and the thermometers numerous.

e A repetition of Smith's experiments with the addition of known amount of air and with the use of very sensitive thermometers. This series should include all commercial vacuums, and the lower end of the steam table should be recalculated with much smaller intervals for use in interpreting the results.

f The expressions radiant heat, latent heat, etc., have been used.

> Sensible heat is defined as molecular motion. Radiant heat has been defined as ether waves. When latent heat is set free as in a condenser, is it molecular or ethereal in its constitution? In chemistry, when an element is set free from combination, there is what is known as the nascent state. Does an analogous action take place when heat is set free from the latent state?

Some of these questions should perhaps be answered by the physicist rather than the engineer, but seem to the Committee to be true engineering problems to be studied through their applications if a complete, reasonable and satisfying theory is to be obtained.

Respectfully submitted,

W. F. M. Goss, *Chairman*
R. C. Carpenter
R. D. Mershon
R. H. Rice
Research Committee

NECROLOGY

HENRY W. BULKLEY

Henry W. Bulkley was born in New York, in July 1842, and died in East Orange, N. J., November 6, 1911. During the Civil War he served in the Navy as assistant engineer, abandoning his studies at the College of the City of New York in order to enlist. At the close of the war he secured employment at the Morgan Iron Works as mechanical draftsman and constructor. Shortly afterwards he opened an office of his own in New York as constructing and consulting engineer and engaged in the manufacture of the Bulkley injector-condensor, superheater, steam pumps, etc., continuing in this work until the time of his death. He was the inventor of the Bulkley injector-condensor, which he patented in 1875, as well as a special type of steam pump and improvements on superheaters.

Mr. Bulkley was a member of the American Institute of Mining Engineers and the American Institute of Electrical Engineers.

THOMAS B. DAVIS

Thomas B. Davis was born at Forest City, Ark., in 1876, and received his early education in the public schools and in the State University of Arkansas. After spending two years as draftsman on steel mill buildings, contracting plants and smelters in Denver, Colo., he studied for one year at Cornell University, securing upon its completion a position as designing engineer with the American Smelting and Refining Company, New York, later going to Mexico as designer and superintendent of erection of the concentration mill at Santa Barbara, Chihuahua. Upon his return he accepted the chair of applied mathematics and machine design at the University of Nebraska, Lincoln, but after a year accepted a position as mechanical engineer with the Jeffrey Manufacturing Company, of Columbus, Ohio. While with this company he made estimates on and designed the cranes for handling the rock, sand, cement and concrete for building the locks at the Isthmus of Panama, manufactured by his company, and in December 1908, was asked by the Government to accompany the United States Engineering Corps to the Isthmus to look over the field and become familiar with the surroundings prior to the beginning of the steel work, one of the most gigantic undertakings in this line ever considered in this country. The success of Mr. Davis's work gave him a wide and enviable reputation for competency in his chosen field. At the time of his death, November 3, 1911, he was president of the Arkansas Farm Company of Little Rock.

JOSEPH JAMES FERRIER

Joseph James Ferrier, whose death occurred at Fruitvale, Cal., October 29, 1911, was born at Brighton, Sussex, England, November 26, 1882. His education was obtained at the English common schools, and in 1904 he completed a course in civil engineering with the International Correspondence Schools, during which time he was also employed by the Linlott Engineering Works, Horsham, England, in their foundry on municipal supplies and agricultural machinery. In 1903 he came to America and obtained a position with the Mergenthaler Linotype Company, Brooklyn, N. Y., as timekeeper, draftsman, estimator and designer. Two years later Mr. Ferrier secured a position in the electrification department of the New York Central & Hudson River Railroad Company, and rose from a subordinate place to chief draftsman in the steam engineering branch of this work. In April 1907, he entered the electrical engineer's office of the Southern Pacific Company, at San Francisco, Cal., taking a prominent position in the steam and mechanical engineering branches of the Oakland, Alameda and Berkeley electrification.

THE ENGINEER AND THE FUTURE

By E. D. Meier, New York

President of the Society

If we could plot the progress of engineering in the last century in a plane curve culminating in the present, at the intersection of our axes the future would probably trace a line ascending in a great parabola.

But as we look back we can conceive of no equation which could express the achievements of the past in a single line, no matter how grand its sweep. The three dimensions which limit our knowledge of space are requisite to compass the varied activities of the engineer.

A century ago the distinction between civil and military engineer sufficed, but a few decades ago it became necessary to differentiate in turn the mechanical and the electrical engineer, while quite recently upwards of a hundred specialties were enumerated in the attempt to define the activities of the profession, each of which has its recognized experts. These are developed to fulfil the imperative demands in every art and industry for a greater refinement, precision and certainty as to the quantity and quality of the product.

Slowly but surely the superstitions and traditions which have so long encumbered our social life and hampered our free development, are exposed and annihilated by the altruistic labors of men who give their life to science. These are the high priests of the new dispensation. It is the duty, the glorious privilege of the engineer to receive their discoveries with reverent hands, and apply them to the solution of the practical problems of life.

Both these types of men are essentially modern products of an evolution which counts not by centuries, but by ages. Before the first Cain of the stone age could appropriate the fruits of his brother Abel's labor there was a mechanic who fashioned his stone axe as patiently as he had lashed the pole to the curved branch with which Abel ploughed. The lame blacksmith who hammered out the greaves of Achilles and chiseled a whole panorama of barbarous

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Presented at the Annual Meeting of The American Society of Mechanical Engineers, December 1911.

deeds on his bossy shield, stood in such high repute among the warlike Greeks that they voted him a place among that rather disreputable coterie which ruled the small world of the day from Mount Olympus. Some centuries later there were a Democritus, a Bion and a Euclid, who developed geometry. But the clumsy method of numerical notation and the absence of algebra made the application to practical problems almost impossible. And the unfortunate habit of the noblest minds among the ancients to lay more weight on methods of reasoning and theoretical speculations than on the facts on which these should be based, retarded the union of science and practice. Even the inventive genius of Archimedes was hampered by these unfavorable conditions.

Those great road and bridge builders, the Romans, produced military engineers, but theirs were mainly static problems; and even their much vaunted aqueducts show lack of coöperation between science and practice. They were carried over valleys on costly structures inviting diversion or destruction at the hands of the enemy. With their excellent cement and their knowledge that water always seeks its level, their engineers might have built subterranean conduits.

The great engineer of the Renaissance, Leonardo da Vinci, with prophetic prescience conceived in the sixteenth century projects which the nineteenth and twentieth were to carry out in the light of scientific facts entirely unsuspected in his day.

The seventeenth and eighteenth centuries were engulfed by wars predatory and dynastic, and even the fierce upheaval of the French Revolution and the drastic destruction of feudalism by Napoleon left alive modes of thought based on an exaggerated reverence for the philosophy of Greece and Rome.

Early in the nineteenth century the scientific method came into vogue, and henceforth problems were studied and defined before their solution was attempted, and more intellectual labor expended in ascertaining facts than on reasoning about them. Thus the union between the mechanic and artificer and the student of nature's eternal laws became possible and permanent, and engineering developed from an art into a profession.

The men who spanned the Hellespont for the hosts of Xerxes, those who dug the irrigation canals which made Mesopotamia the granary of the ancient world, those who designed and built the engines with which Alexander battered the walls of Persian strongholds, those who cumulated the puny muscular force of thousands of

Egyptian slaves for the herculean task of raising the pyramids, all these men were giants in their day; but now their very names are forgotten. The literature of that day and for long afterward was concerned mainly with kings and conquerors. Jurisprudence and medicine shared in some slight degree the attention and prestige which were almost wholly absorbed by war, and can hence trace their history back to the ancient world. Democritus was one of the few ancients with scientific bias; knowing his surroundings we can understand why he became the "laughing philosopher."

Engineering is the profession of the present, and will dominate the future.

Laws have been made by men ever since the family expanded into the clan or tribe. They naturally reflect the ethical standard of the average mind of the period. Far in advance of them are the precepts laid down by those who founded the great religions of the world. And as we reverently discover and apply natural laws, we find new reasons and supports for these fundamental ethical conceptions.

The engineer then is a devout believer in natural laws. He knows that they are immutable and permit no exceptions. He needs no Supreme Court to define them as reasonable. They are the very foundation of the universe, and reason itself owes its existence to them. Every infraction of them brings its own punishment. The knowledge that every mistake or neglect inevitably results in failure is ingrained in the very fiber of his being. The vile doctrine evolved in the dark ages, "the king can do no wrong," which still causes occasional lapses of justice, has no meaning for the engineer. To tell the truth is not merely laudable and salutary, it is essential and necessary. To lie is not only wicked, it is ineffectual, absurd and ridiculous.

To men thus trained, the future of the race is to be confided. They are not to be merely learned men; they must possess knowledge. Those fundamental sciences which observe and explain the interrelation of matter and force, which weigh the distant planets and measure the wave lengths of sound and of light, must be the absorbing objects of their nightly vigils and their all-satisfying reward.

The savage hated work, and even in those golden periods, praised by romancers masquerading as historians, labor was despised as the doom of the slave. As progress demanded more and higher types of labor, various devices were invented to secure it. From the glass beads and the brass bangles of the Hottentot to their counterparts in polished stone and burnished gold in civilized communities, these devices were effectual; but the highest type of labor has never been purchased by such crude bribes. The enlightened man loves his work and finds in it his supreme incentive.

To a Copernicus or a Newton, a Watt or a Corliss, an Ericsson or a Fritz, an Edison or a Steinmetz, the ransom of a king would seem trivial compared with the satisfaction of knowing that he has given to his fellow men an achievement which marks a forward step in the evolution which will finally make us a race of rational beings.

When the "missing link" stood erect, walked and essayed articulate speech, this evolution began. The first man had crude but strong desires, and was a strenuous individualist. The predatory instinct was predominant, and the success of the family, the clan, the tribe, and finally the nation, depended on the potent warrior at its head. Laws and customs modified this predatory individualism in each community, but between neighboring communities there still held the rule, that

"He shall take who has the power,
And he shall hold who can."

The right of the mailed fist is still occasionally invoked by great nations, even though the individual citizens have been tamed and domesticated.

Commerce, which has in large measure wrested the control of the world from the war lords, has always had as its basic principle the rule, "Buy as cheap as you can, sell as dear as you can."

This has worked fairly well when cargoes of grain, wool, cotton, hemp, etc., were concerned. But where this principle was ruthlessly applied to the great producing industries of the world, where the comfort of the worker, the maintenance of his family, the very existence of his helpless children were in jeopardy, it has caused havoc, bred discontent and fomented revolution. No one who has worked among the contented, intelligent mechanics of a half century ago can view without distress and indignation conditions as they exist today. Labor unionism is a protest, dangerously near a rebellion, but not a cure.

When the commanders of the industrial soldiery wrought in their midst, understood their problems, solved their perplexities, aroused and shared their enthusiasm for the quality of the product there grew up an esprit de corps which is now sadly missing.

Without faith in the excellence of the goods produced, without enthusiasm in the work and in the leaders, productive labor becomes mere drudgery. The remedy lies in placing engineers in all the responsible positions in these great industries. Their special training fits them for leadership in this host; and leadership by him who knows, and who sinks himself in his work, always has and always will command that joyous and fervent support from his followers which money cannot buy.

Where nepotism is banished, and ability and perseverance are recognized, there great success is attained. Napoleon's army, the Carnegie Steel Works, the Pennsylvania Railroad, exemplify this. The increasing multitudes of special industries are literally hungering for engineers equipped with character, knowledge and devotion, to become the expert leaders.

Labor wars will cease when such men are given the power to provide that the share in the rewards of industry shall bear just ratio to the service rendered the community. There is a sane middle ground between grasping individualism and utopian socialism.

The forces and materials we employ in our manufactures have long been and still are the subjects of most careful analysis and experimentation, to find their precise load capacity and endurance. The study of the living force and of that highest and most costly material inherent in the workman has but recently begun. But already several promising theories are undergoing exhaustive tests on a large scale. Psychological study prescribes a humane basis for them all as the condition of success.

The unrest in the modern world has its basis in an underlying sense of injustice. The growing sense of community of interest, the knowledge of our dependence on each other, the ever-expanding humanitarianism, are all founded on scientific facts, and are becoming world movements. They fervently and emphatically answer Cain's question, "Thou art thy brother's keeper."

The engineer is responsible for the vast increase in appliances to meet every demand of that most voracious of living beings, man. The mass of mankind needs to be educated to understand and use them properly. He is in honor bound to supply this education; and as the crude dangers and fears of the earlier centuries vanished, so the prejudices and superstitions of the Dark Ages must be swept away.

If our future professional brethren do their duty, and we know they will, the golden rule will be put in practice through the slide rule of the engineer.

SYMPOSIUM ON WELDING

MODERN WELDING PROCESSES

WITH SPECIAL REFERENCE TO FLAME WELDING

By H. R. Cobleigh, New York

Junior Member of the Society

Welding may be divided into two general classes, pressure welding and casting. The oldest and commonest process, where the forge is used for heating and the uniting of the metals effected by hammering, belongs to the first class, and only one of the newer processes, electric resistance welding, comes within the same classification. The pioneer in the second class was "burning on," a process of local casting where the parts to be united were first preheated to a state to amalgamate with molten metal poured in to complete the joint. Another electric process, arc welding, and all of the gas or flame-welding processes, belong also to this second class.

2 A distinction in procedure differentiating the older from the newer processes is, in a measure, the greater portability of the latter; more exactly, in the older processes the work is brought to the heat, or the source of the heat is apart from the immediate vicinity of the place where the welding is done, while in the newer processes the reverse is true.

3 Autogenous welding has become the accepted name for arc, flame and sometimes thermit welding, but it is a misnomer. Strictly speaking the term means either self-welding, which is ridiculous, or welding with the same metal, whereas two different metals are often united, sometimes with a third metal, and the result is not comparable with brazing or soldering as there is a more intimate molecular union. In the real sense of the word it is not welding, for there is no compression, or hammering, except incidentally as practised by some in the belief that it improves the structure of the added metal. It is more analogous to casting, since the union is made by the flow-

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ing together of the metals, but that word alone is even more ambiguous. Fusion welding would be a good term but it has been appropriated by another new process abroad which is more akin to brazing. However, as that process does not appear to have taken any important place in the arts, there is probably no reason why it should not be applied to what is now called autogenous welding, or auto-welding for short. One of the simplest definitions of autogenous welding is the uniting of metals by heat alone.

THERMIT WELDING

4 Thermit welding is the outcome of the discovery in Germany about the beginning of this century that a mixture of finely divided metallic oxides and aluminum, when ignited at one spot, react to form a new combination of aluminum oxide and free metal, formerly in the oxide form, due to the greater affinity of the aluminum for oxygen. This reaction is accompanied with an evolution of heat in which a temperature of 5400 deg. fahr. is obtained. In the resulting molten mass the lighter aluminum oxide rises to the top where it can be skimmed off as slag, leaving the other metal in a superheated state, which, when poured into a mold surrounding the parts to be joined, contains sufficient excess heat to bring those parts to the point where they will amalgamate with the added metal, so that the whole solidifies as a homogeneous mass. Usually, however, it is advisable to preheat with a gasolene torch the parts to be joined, and thus by eliminating the gases produce a better casting.

5 The commoner form of thermit contains iron oxide and aluminum, and the reaction follows the formula $Fe_2O_3+2Al=2Fe+Al_2O_3$.

ELECTRIC WELDING

6 Beyond the fact that electric current is used for obtaining the welding temperature, the two kinds of electric welding, arc and resistance, have no similarity. Comment on the electric processes will be limited in this paper to the electric resistance welding. The principle discovered by Elihu Thomson involves the passage of electric current through the abutting ends of the pieces of metal to be welded, thereby generating heat at the point of contact, which also becomes the point of greatest resistance, while at the same time applying pressure to force the parts together. As the current heats the metal to the welding temperature at the junction the pressure follows up the softening surface until a complete union or weld is effected. It is claimed that in all other processes, the heat not being

generated in the metal or in the joint to be welded, is largely dissipated and wasted. In the Thomson process the heat is generated in the metal itself at the joint, and practically confined there; the energy is therefore economically employed. When the weld is made, the structure of the metal at the joint is the same as elsewhere. The metal can be held at any temperature desired for any length of time and the heat increased or decreased at will. The metal while heating is visible in the open air. Being unattended with smoke, heat or dirt, the apparatus employed can be located wherever convenient or desirable.

7 Various forms of machines are built, but the main essentials in all of them are a transformer provided with a pair of clamps aligned with and insulated from one another to hold the pieces to be welded, and mechanical, hydraulic or other means to force the abutting ends of these pieces together. In some forms there are additional mechanical features for shaping the weld after it is completed to remove the fin, as by striking between two dies. Contrary to ordinary welding, the heat begins at the interior and travels to the exterior, impurities thus being expelled. There is no current expense except when heating, little to wear or occasion repairs, and unskilled labor can operate the machines. A reactive coil is used for controlling the current in the welder for varying sections of stock to be welded. In the smaller types the pressure is applied and the current shut off automatically. In all but the smaller types provision is made to maintain a circulation of water in the secondary circuit for cooling purposes. By means of a break-switch the circuit is opened and closed in the primary of the welder; in some types automatically.

8 The apparatus is built in sizes and types suited to the kind and section of the metal to be welded, these usually ranging from small wire to sections of 3 sq. in. Only alternating current is used, taken from a single phase of any constant potential, 40 to 60 cycle, between 100 and 500 volts. In general the process is particularly applicable to the butt welding of relatively small and similar sections, i. e., the parts to be joined should be of approximately equal cross-section. Among the most common in the very wide range of applications of this process are the welding of metal tires of all kinds and other parts in the running gear of wagons and carriages, bicycle parts of all kinds, parts of tools, wire of all kinds for such purposes as hoops, fencing, etc., pipe chain, parts used in street railway construction, miscellaneous automobile parts, and the like.

9 Fig. 1 shows a semi-automatic welder for wire, with the sides of

the base removed to expose the transformer. Figs. 2 and 3 are front and rear views respectively of a chain welder installed for the Yale & Towne Manufacturing Company, and used for welding the links of hoist chain, and a slightly different machine for welding seamless tubing is shown in Fig. 4.

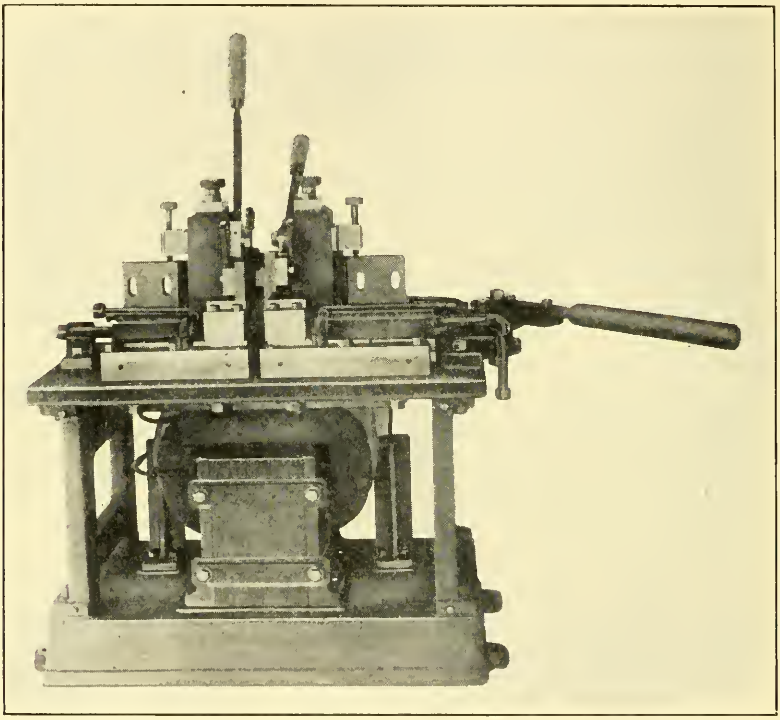

Fig. 1 Thomson Semi-Automatic Electric Welder for Wire

10 The output of a single machine varies according to the size of the weld and the shape of the pieces to be welded, and depends in a great measure upon the operator. If the work is light and takes little time to adjust in the machine, very large outputs are possible. The horsepower and time required to make a given weld vary nearly as the cross-sectional area. Within certain limits the greater the power the less the time, and vice versa. With 15 kw. a $\frac{3}{4}$-in. round can be welded in 15 seconds and with 23 kw. in 6 seconds. Endless pieces like rings take more power as the diameter decreases; copper more power and less time than steel or iron.

11 Table 1 from the catalogue of the Thomson Electric Welding Company gives the approximate normal power and the time (for the application of the current only) for various sections. Multiplying the kilowatt-hours by the cost of the current in cents per kilowatt-hour will give the current cost for 1000 welds.

12 One of the latest applications of the process is the welding of platinum points on steel and brass pins. The manufacturers' principal line of endeavor now is to increase the rapidity of working and reduce the cost of operation. At present butt machines are operating at a rate of 20 welds a minute, and point welders making five to ten welds at a time and working automatically. Spot, point, ridge and jump welding are inventions of the Thomson Company, which is now building machines for this work. A rather new commercial develop-

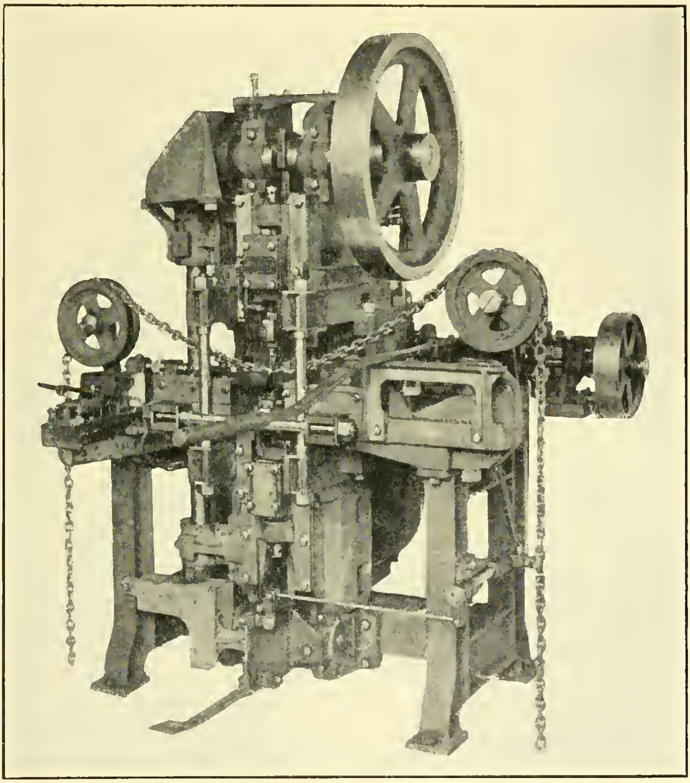

Fig. 2 Front View of Electric Chain Welder

ment in electric welding is that of welding halves of casters, handles, etc., in semi-automatic machines to make the whole article. The smallest Thomson machines weld No. 23 wire and the largest sections of 3 sq. in.

TABLE 1. APPROXIMATE NORMAL POWER AND TIME FOR VARIOUS SECTIONS

Iron-Steel Round Rod	Area	Horsepower	Kilowatt	Seconds	Approximate Kw-Hr. 1000 Welds
1/4	0.05	5	4	2	2
3/8	0.11	8	6	3	5
1/2	0.20	12	9	6	15
5/8	0.31	16	12	10	30
3/4	0.44	20	15	15	65
7/8	0.60	24	18	18	90
1	0.79	26	20	20	113
1 1/8	0.99	33	25	24	167
1 1/4	1.23	40	30	33	275
1 1/2	1.77	50	38	40	422
1 3/4	2.41	64	48	48	640
2	3.14	80	60	60	1000

FLAME WELDING

13 Of the different kinds of torch or blowpipe welding, the two of the greatest present commercial importance are oxy-hydrogen and oxy-acetylene. Air-gas and oxy-gas (coal gas) torches are also used, but they do not give as high temperatures as either the oxy-hydrogen or oxy-acetylene torches and are generally considered not well adapted either to welding or cutting, but useful mainly for soldering and brazing. Another flame process, which, as far as the author is aware, has never been introduced into this country, uses "liquid gas," discovered by M. M. Wolf of Basseldorf, Switzerland. The oxy-liquid gas flame is claimed to give a temperature of 7000 deg. fahr., which is even higher than oxy-acetylene (6300 deg. fahr.). It is declared to contain 2500 more thermal units per cubic meter than acetylene. The flame of the oxy-liquid gas torch has much the same appearance as the oxy-acetylene flame. Blau gas which has been introduced in this country seems to be closely analogous to liquid gas and gives the same temperature. Its possibilities for welding and cutting give great promise.

14 Liquid gas is obtained by distilling heavy oils such as paraffin oils, crude petroleum and the like. The distilling and cleaning processes are the same as in the manufacture of any oil gases. Wolf's special process involves the abstraction of heat and the employment of pressure to separate the gases that are the hardest to liquify, as hydrogen, methane, etc., from those liquified more easily, such as

ethane, propane, pentane, etc. It is charged into steel bottles at 1200 to 1500 lb. pressure, making it again liquid, from which state it gasifies readily at atmospheric conditions into dry inflammable gas, containing none of the poisonous hydrocarbons. It consists principally of ethylene and ethane, with small quantities of methane, benzol, air and carbon dioxide. It is explosive only in mixtures containing 4 to 9 per cent of gas, hence is much less likely to explode than city gas or acetylene. Being 1.027 times heavier than air it does not easily mix with air, which still further reduces danger of explosion.

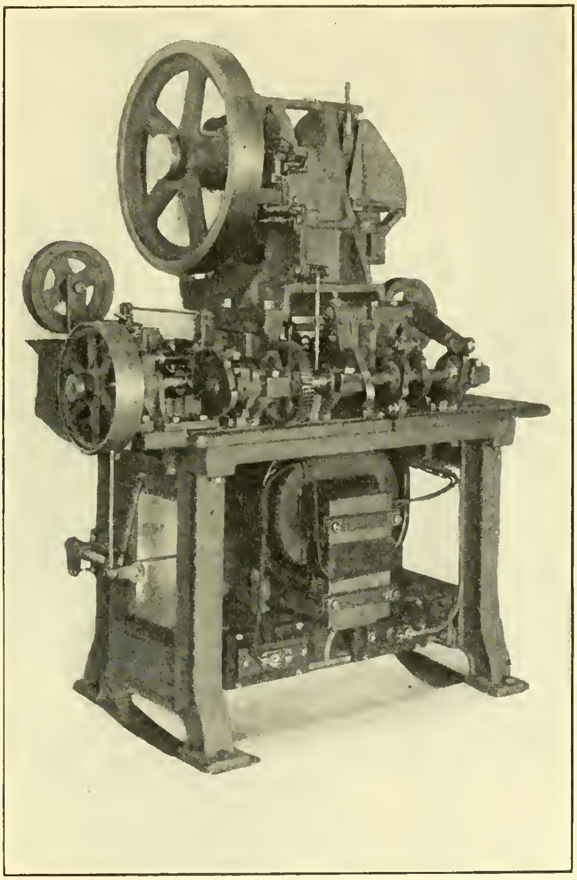

Fig. 3 Rear View of Electric Chain Welder

15 The torch with which this gas is used does not require as great provision against back-firing as the oxy-acetylene torch. An air chamber keeps the handle cool, through which the gas and oxygen are passed to a mixing chamber in the front half of the body of the torch. At the rear of this chamber the gas is carried through a pipe coiled around the stem of the torch, and in this way is preheated. Oxygen passes out the forward end of this chamber through another pipe which meets the gas pipe at the nozzle of the torch. Through the central stem is carried the mixed gas, and the three are combined at the nozzle into a good mixture for combustion. Only three tips are needed for welding or cutting any thickness. The cutting torch has the usual high-pressure oxygen supply and does not require the preheating coil for the gas. Neither the gas nor the products of combustion attack metal, hence the burners, torches and fittings last a long time, and the gas does not injure the metal in the joint, so that strong welds result.

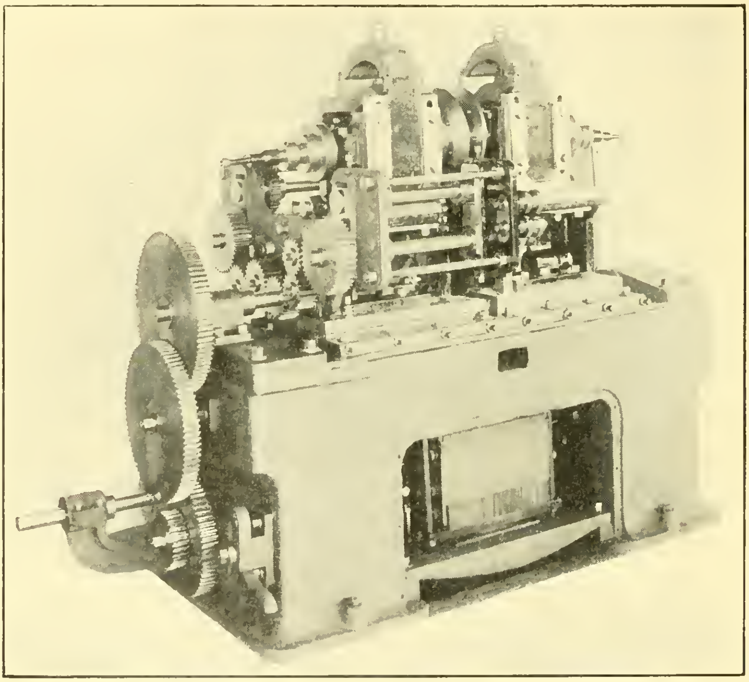

Fig. 4 Machine for Electric Welding Seamless Tubing

THE OXY-HYDROGEN PROCESS

16 The oxy-hydrogen process, although older than the oxy-acetylene process, has not been developed quite as rapidly, although for certain applications it has the advantage of its competitor. The torch is simpler because flame propagation in hydrogen is not as rapid as in acetylene and less precaution is necessary to prevent flash-back. In fact all that is necessary in such a torch is two conduits for the gases with a common nozzle from which they are discharged mixed. In its simplest form we are all familiar from our laboratory days with the oxy-hydrogen blowpipe. Any refinements that have been introduced since the industrial application of the torch has been appreciated have had for their object greater convenience in handling, directing or controlling the flame, according to the work to be done. For all purposes where the greater heat intensity of the oxy-acetylene torch is of no advantage, the oxy-hydrogen torch with its temperature of about 4000 deg. fahr. is as good or even better. For example, it is capable of cutting greater thicknesses of steel and wrought iron, on account of the greater penetration of the flame, and for thin welding and the welding of metals of the lower fusibilities less skill is required in its handling. Another advantage is that it makes use of a by-product of electrolytic decomposition of water, one of the best methods of procuring the purest oxygen, and a process that is becoming of important commercial significance for making oxygen for the acetylene torch as well. Further, the hydrogen can safely be compressed directly into tanks for carrying on outside operations or supplying any portable outfits, whereas acetylene, as will be explained later, must be dissolved in acetone to be handled safely when compressed above two atmospheres.

17 Perhaps the reference to hydrogen as a by-product of the electrolytic production of oxygen should be modified so far as the oxy-hydrogen process is concerned, for the fact is that more hydrogen is required than the proportion of two to one as found in water, so that there is an excess of oxygen, making this gas in that sense the by-product. The reason for this is that although hydrogen in burning returns to the form of water (or its vapor), part of the oxygen is obtained from the surrounding air, hence to prevent the flame from oxidizing the work, the supply of pure oxygen through the torch is proportionately reduced. However, the excess oxygen, if not all needed for cutting operations, will find a ready market among the users of oxy-acetylene apparatus not making their own oxygen. Then, too, it has been reported quite recently that means have been

found for carburetting the hydrogen, so that where welding alone is done the consumption of oxygen and hydrogen leaves no excess of either and the flame produced is of greater heat intensity than with the plain hydrogen. The ideal arrangement would seem to be the providing of all three gases, oxygen, hydrogen and acetylene, in plants of a size to warrant it, employing apparatus for the electrolytic production of the first two gases and an acetylene generator,

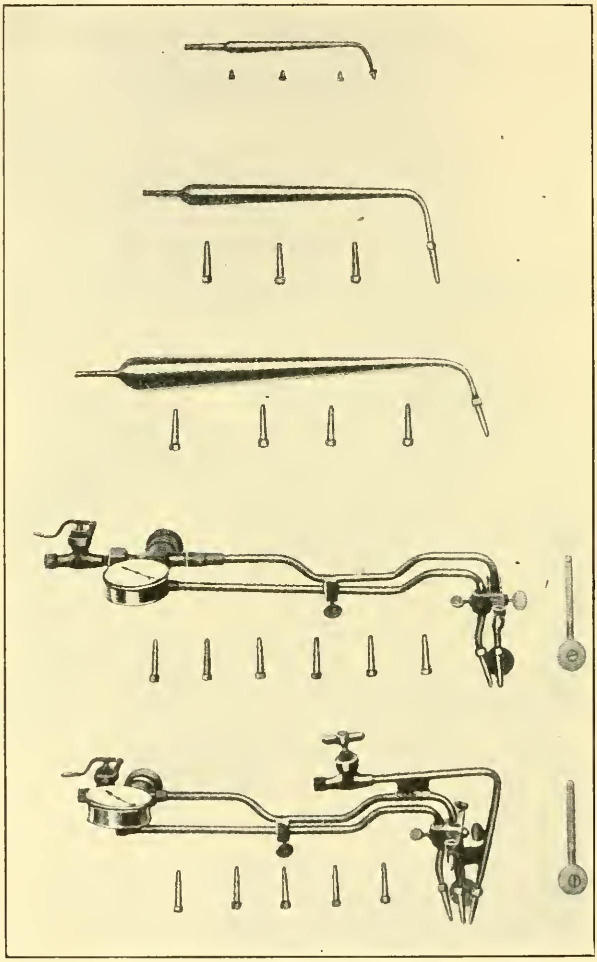

FIG. 5 GROUP OF OXYHYDRIC WELDING AND CUTTING TORCHES

and using the oxy-hydrogen and the oxy-acetylene torches on the work for which each is the best adapted. There is a sufficient overlap in the profitable applications of each to introduce no difficulty in the proper relative consumption of the several gases. One of the oxy-acetylene torch manufacturers, the Davis-Bournonville Company, is now arranging to manufacture oxy-hydrogen apparatus, appreciating the value of their correlated use.

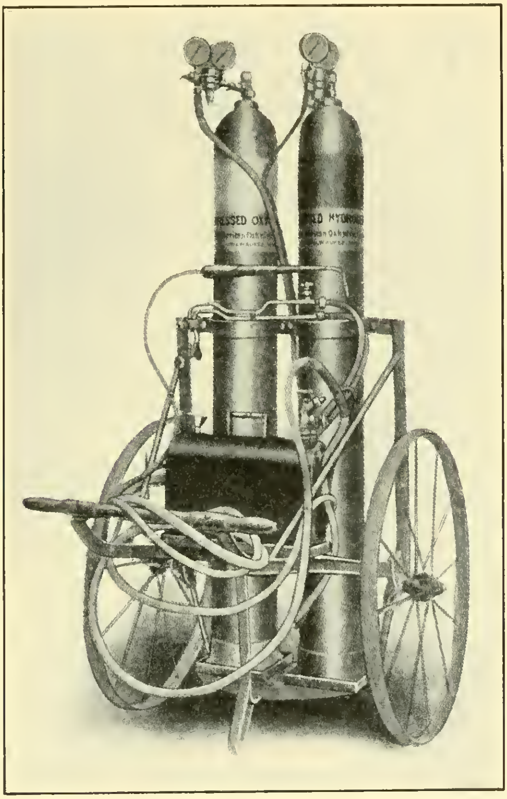

Fig. 6 Portable Oxyhydric Apparatus for Cutting and Welding

18 The American Oxyhydric Company, Milwaukee, Wis., a leader in the introduction of the oxy-hydrogen welding process in this country, is responsible for the following rather interesting definitions and divisions of welding:

Welding may be divided into two classes, autogenous and heterogeneous.

The former term applies when metals are united without either flux or compression, the latter when the union is effected by interposing an alloy, usually more fusible than the metal which is to be welded. Autogenous welding may again be divided into two classes, one welding by forging, and the other by fusion with the aid of a blowpipe, electricity or alumino-thermite.

It further states that autogenous welding is particularly effective when applied to iron, steel and lead, and heterogeneous welding is used most effectively on zinc and copper, its argument being that metals which oxidize at a temperature close to the fusion point should be welded by the heterogeneous process.

19 Fig. 5 shows a group of this company's welding and cutting torches. This torch is distinguished by the fact that the mixture of the gases occurs before their admission to the torch, there being a hose between the mixer and the torch. Safety against back-firing is secured by discharging the gases at a speed greater than that of the flame propagation in the mixture and limited for its maximum by that which would tend to blow away the metal as it is melted in the weld. A portable oxyhydric apparatus for both cutting and welding is shown in Fig. 6.

GAS PRODUCTION

20 The American Oxyhydric Company has the American-Canadian rights for the Caruti system for producing oxygen and hydrogen. The process is one of decomposing water by an electric current in which oxygen is claimed to be obtained at 96 per cent purity and hydrogen at 100 per cent. The oxygen is further purified to over 99 per cent purity, the remaining impurity consisting of hydrogen. These gases are shipped to consumers in steel cylinders of 200 to 250 cu. ft. capacity. Regulators and gages are provided to reduce the gases to working pressures and show the state of depletion of the gases in the cylinders.

OXY-ACETYLENE WELDING

21 Le Chatelier has the credit of having first called attention to the high temperature obtainable in the combustion of acetylene with oxygen. This was in 1895. The discovery was not taken advantage of until 1901, when Fouché and Picard brought out a torch in which they diluted the acetylene to prevent back flashing. The following year they overcame the necessity of dilution by employing a high-pressure torch which emitted the gases at such a velocity that the flame could not strike back. This, however, was difficult to use because it blew the metal away as fast as it was melted. In 1903

Fouché introduced the low-pressure torch still familiar as such, in which the oxygen only is under appreciable pressure and the acetylene is drawn in by injector action. About the same time Camille Rodrigues-Ely and Emile Gauthier announced their intermediate pressure torch, which is known in this country as the high-pressure torch, because the one of still higher pressure has never been introduced here.

22 The first commercial installation in this country was made at the Fore River Shipbuilding Company, Quincy, Mass., in 1905, by André Beltzer, then with the Industrial Oxygen Company, the pioneer in introducing the process here. The second plant installed by it was the Worcester Pressed Steel Company. Here the Epurite process for producing oxygen was used, which with the Industrial Oxygen Company's later oxygenite process is referred to at greater length in Pars. 45–47. The torches were of the intermediate pressure type.

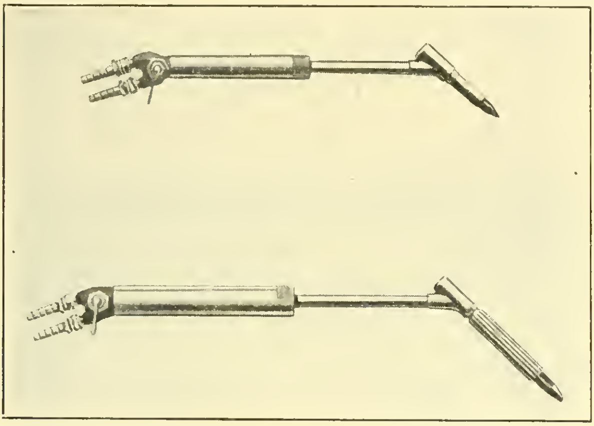

Fig. 7 Linde Form of Fouché Oxy-Acetylene Torch

23 The Fouché or low-pressure torch is the form used by the Linde Air Products Company, which gave a very great impetus to the flame-welding and cutting arts when it placed oxygen on the market at a moderate price. The process is one of obtaining it by separation from the air, and is also referred to more extendedly in Par. 51.

24 The third in the field was the Davis-Bournonville Company, which for some time had been investigating the developments abroad,

particularly in France, and which acquired the American rights for the Rodrigues-Gauthier medium-pressure type of torch.

TORCHES

25 What are commonly spoken of as low-pressure and high-pressure torches are better classified as injector and pressure, or positive-mixture types, as this is the chief distinction, indicating the manner in which the acetylene is taken in. As explained in Par. 21, the Fouché is an injector torch. The oxygen admitted under pressure draws in the acetylene after the familiar action of a steam injector, and by the law governing the action the quantity drawn in depends on the square of the velocity of the oxygen jet. It is argued by advocates of the other type that it is not easy to maintain the proper relative proportions of the two gases with this torch since any variation in the diameter of the final outlet of the nozzle (as by expansion, if it becomes heated during use, or by the adherence of molten particles to the end) alters the velocity of the oxygen and so the amount of acetylene injected.

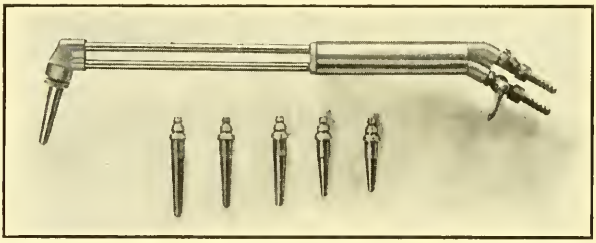

Fig. 8 Davis-Bournonville Positive-Mixture Torch

26 The pressure-type torch introduces both gases under pressure and the proportion of the mixture can be varied by varying either pressure. The pressures on the gases, never over a few pounds, will depend on the size of the torch, which in turn is determined by the character of the work and the size of flame needed. These torches must either be supplied with dissolved acetylene or from a pressure generator, whereas the injector torches can take their supply from an ordinary lighting generator. Fig. 7 shows the Linde form of Fouché torch and Fig. 8 the Davis-Bournonville positive-mixture torch. The feature of the latter is the proper proportioning of the inlets to the nozzle for the two gases. As shown in the sectional view, Fig. 9, the oxygen enters at *a* in a straight line and passes through a

restricted opening before emerging into the mixing chambers, while the acetylene enters laterally through four holes *b*, and joins the stream of oxygen and mixes with it in the slightly larger bore of the mixing chamber where the velocity is correspondingly reduced, giving time for the mixture. It will be seen that the proportion of the two gases is entirely independent of the orifice diameter at the final outlet. The tips are interchangeable so that different sizes may be used in the same torch for different work.

27 The handles of all torches are now packed with porous material such as asbestos or mineral wool, or by some other means secure finely divided openings for the passage of the acetylene. An interesting construction is that of the Goodyear torch, Fig. 10, which has a piece of clock pinion wire inserted in a bore of its outside diameter, giving a number of small parallel holes for passing the acetylene.

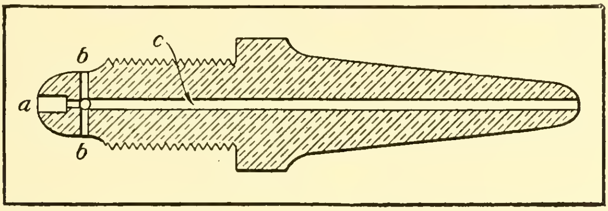

Fig. 9 Sectional View of Davis-Bournonville Torch

The principle is that of the Davy safety miners' lamp in preventing propagation of the flame backward, that might lead to the explosion of the acetylene generator if it happened to contain air. There are other safety provisions, however, between the torch and the generator, so that practically all danger of acetylene explosions has been eliminated except where gross carelessness in the use of the apparatus is practised. The first low-pressure Fouché torch prevented flash-back by passing the acetylene through a relatively small bore tube coiled in the handle.

28 Some favor a torch with its end at right angles with the body to allow wrist motion, but most torches have the tip inclined at about 45 or 60 deg.

THE TORCH FLAME

29 For the complete combustion of acetylene there is required two and one half times its volume of oxygen as shown by the formula $C_2H_2+5O=2CO_2+H_2O$. This is not the proportion, however, in which the two gases are supplied to the torch, for the reason that the

complete reaction takes place in two stages represented by the two parts of the flame, the intensely luminous inner cone at the tip of which the maximum temperature of about 6300 deg. fahr. is reached, and the pale almost transparent envelope of the flame where the temperature is very considerably lower. In the inner cone the reaction is $C_2H_2+2O=2CO+2H$, and its high temperature is accounted for by the liberation of heat both by the dissociation of acetylene and the formation of carbon monoxide, the acetylene being endothermic and the monoxide exothermic. The carbon monoxide and the hydrogen cannot combine with more oxygen in the inner cone because its temperature is above their dissociation points, so this further combination occurs as a second stage in the reaction in the envelope of the flame and is represented by the equation $2CO+2H+3O=2CO_2+H_2O$. Most of the oxygen for this second reaction is taken from the surrounding air, hence the smaller quantity required through the torch. It is a singular fact that the injector type of torch uses oxygen in the proportion of 1.5 or 1.7 to 1 of acetylene, while the pressure torch requires only 1.28 of oxygen to 1 of acetylene. The old high-pressure torch used the gases in the theoretical propor-

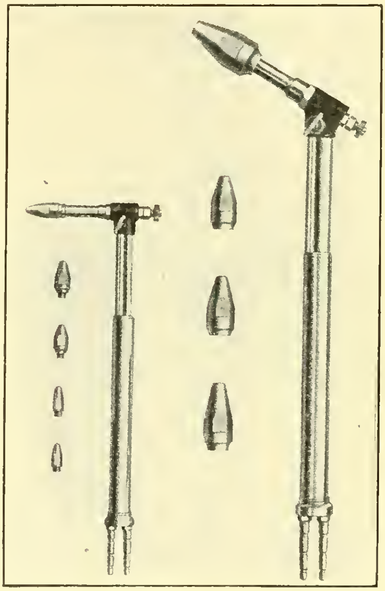

Fig. 10 Goodyear Oxy-Acetylene Torch

tions for the inner cone reaction of 1 to 1, indicating that it evidently accomplished a perfect mixture of the gases before their discharge.

30 The tip of the inner cone is the working point of the torch. Although its temperature is so much higher, the total heat in the inner cone is less than that in the outer envelope, the latter being very much larger. It might seem that the heat in the envelope is wasted, but such is not the case for it serves two functions, to preheat the work for the inner cone, and to prevent the latter from being cooled by the inert nitrogen forming about 80 per cent of the air. Further the envelope is a protection for the molten metal from oxidation, the combining monoxide and hydrogen having a greater affinity for oxygen than the metal.

31 In the use of the torch it is very important to maintain a neutral flame, that is, one having neither an excess of acetylene nor of oxygen, as the first would carbonize the work and the second oxidize it. The proper condition of the flame is easily determined by observation, and the gases can be regulated accordingly. With an excess of acetylene there will be two inner cones, one extending beyond the other and less luminous. By reducing the acetylene pressure the second cone will recede and when it finally coincides with the first, or disappears, the flame is neutral. When the adjustment is exact the inner cone will have a sharply defined contour and a slightly rounded point. With an excess of oxygen the flame has a violet cast and the end of the inner cone is feathery. Excess of either gas can also be detected by the appearance of the work. If the flame is carbonizing the metal will glow intensely, and if oxidizing the metal will boil.

ACETYLENE GENERATION

32 All methods of acetylene generation are alike in the materials used, calcium carbide and water. While any carbide could be used, the calcium form is the only one obtainable on the market in large quantities and at a reasonable figure. It is a product of the electric furnace, being formed only at a very high temperature from a mixture of ground coke and lime in the proportions of 9 to 14 by weight. The reaction is $CaO+3C=CaC_2+CO$.

33 When calcium carbide and water are brought together acetylene is evolved with slaked lime as a residue expressed by the following equation: $CaC_2+2H_2O=Ca(OH)_2+C_2H_2$.

34 Commercial carbide yields from $4\frac{1}{2}$ to 5 cu. ft. of acetylene per lb. Lump carbide in sizes of $1\frac{3}{4}$ x $\frac{3}{8}$ in., known as "nut," is claimed to yield from 5 to 15 per cent more acetylene than finely divided

carbide, probably due to more or less slaking of the latter by moisture in the air. For that reason generators capable of using the lump carbide claim a certain advantage over those limited to the use of the crushed form.

35 Two kinds of generators are used known from their manner of feeding as water-feed or "water-to-carbide" generators and carbide-feed or "carbide-to-water" generators. The first is very little used because of the disadvantage that the apparatus gets very hot and the gas is not likely to be so good. This is due to the tendency of the gas to become overheated and to some extent to be converted into oily matters, an effect known as polymerization. Where this has occurred it is indicated by a yellowish or brownish staining of the residue. It can be avoided where care is taken properly to water-cool the apparatus.

36 An example of the most approved apparatus of this type is that recently installed in the Santa Fé shops at Topeka. It consists of cylindrical iron cells placed horizontally, each fitted with galvanized iron drawers of six sections for holding carbide. The water is admitted to each of the end sections and the gas generated is carried away in pipes. When the carbide becomes exhausted in the end cell, sufficient water has accumulated to run through a V-shaped opening in the partition to the next section, after which the drawer is withdrawn and recharged. As a cell is opened the water supply to it is automatically cut off. These generating cells are kept submerged in running water to keep the temperature of the gas as low as possible. Any cell can be inspected or recharged without interfering with the operation of the others. The gas is further cooled and washed by being passed through water before it reaches the holder.

37 Where the reverse manner of feeding is used and the carbide is dropped into the water, the gas is washed as it is evolved and it and the apparatus kept cool. In these generators it is well also to have an abundant supply of water in the bottom. The generally accepted rule now is a gallon of water to each pound of carbide.

38 The carbide-feed machines may again be divided into two classes, gravity feed, where some sort of a valve is used to release the carbide, and forced feed, where usually by means of clock work the carbide is forced off a plate or some similar device. In both types the action of the feed is dependent upon the pressure of gas within the machine. As it falls more carbide is dropped into the water and as the pressure rises the feeding is arrested. Both generate acetylene at sufficient pressure to be used directly in the pressure or positive-

mixture types of torches. A necessary feature of all types of generator is a water-sealed flash-back chamber or its equivalent to make communication of the flame to the generator impossible. Safety devices interlock the various movements of valves operated when recharging the machines. All in all it would seem that aside from inexcusable carelessness any generator approved by the National Board of Fire Underwriters can be installed and used without danger to life or property.

39 Low-pressure generators such as are used for lighting are suitable for supplying torches of the injector type. Their principal difference from the types just referred to lies in the feed control, which is usually by a bell instead of a pressure diaphragm.

40 Where a generator is carried on a portable outfit the water-to-carbide type is probably the safest, since a carbide-feed type would be more likely to generate gas when jarred. Some argue that a generator should never be carried on a portable outfit, but that compressed gas tanks should be used. This calls for the explanation that whenever compressed acetylene is spoken of what is meant is dissolved acetylene, for the gas becomes very explosive when compressed to above two atmospheres. In 1896, Claude and Hesse, two French engineers, discovered that acetone is a remarkable solvent for acetylene. For each atmosphere of pressure it will dissolve 25 times its own volume of acetylene, and in this condition the latter is not explosive under heavy pressure. The acetone is placed in tanks containing porous material so that there are no spaces for the gas to separate and collect in, and the acetylene is compressed into them. Acetylene in this form, although costing twice as much as when generated, is very convenient in outside repair work where portability is a feature.

41 Of all hydrocarbons, with the possible exception of liquid and Blau gas, acetylene possesses the greatest proportion of carbon, 92.3 per cent, the remaining 7.7 per cent being hydrogen. It is therefore most nearly gaseous carbon, for there is no known means of obtaining a high enough temperature to gasify pure carbon. It gives about five times as much heat per cubic foot as hydrogen and a flame of greater intensity, the temperature being, as has been mentioned before, 6300 deg. fahr.

OXYGEN GENERATION

42 Oxygen generation is of three classes, chemical, electrolytic and atmospheric, to each of which except the second there are subdivisions.

43 Chemical oxygen production is of two kinds, wet and dry, and of each there are several variations. The wet process at the Santa Fé shops consists of boiling in a water-tight tank, a saturated solution of bleaching powder, or calcium oxychloride, to which is added at regular intervals a saturated solution of 5 parts iron sulphate and one part copper sulphate. A mechanically operated paddle, agitating the mixture, facilitates the release of the gas. The oxygen passes off at the top and the residuum remains in solution to be drawn off before the tank is discharged. The water in the tank is heated by the exhaust steam from the oxygen compressor. From the generator the oxygen is passed to a water scrubber to remove the chlorine and foreign matter, and for a final cleaning the gas is passed through a second scrubber containing a solution of caustic soda, which also serves as a water seal to the gasometer to which the clean gas is delivered, and from which it is drawn by the compressor and stored in tanks at a pressure of 85 lb.

44 The Lavoisite process is another of the same class, which, however, evolves oxygen directly under pressure by the simple addition of hot water to a powder of secret composition. The Sowers Manufacturing Company, which introduced it, recently sold the rights to the Davis-Bournonville Company. The Lavoisite powder is received in a drum which is inverted over the top of the generator and connected with it by means of a special valve arrangement in connection with the cover of the drum. The contents of the drum are discharged into the generator, the drum removed and the generator manhole cover replaced and screwed down. Hot water is then pumped into the generator until the charge is exhausted, the oxygen in the meantime passing through a scrubber to the distributing main or storage tanks. When the generation is complete the hot water is shut off and cold water pumped in until all of the gas remaining in the generator is displaced. When the generator is clear it is ready for a new charge.

45 Still another wet process used a powder sold under the trade name of Epurite, a mixture consisting of 20 parts chlorate of lime, one part sulphate of copper and three parts sulphate of iron, which when brought into contact with water evolved oxygen. One pound of the material produced about 8 cu. ft. of oxygen. The generating apparatus deteriorated so rapidly and the cleaning of it was so mussy that it was soon abandoned.

46 The most common chemical process is the dry evolution of oxygen under the influence of heat from a mixture of 100 parts by

weight of crystallized chlorate of potash and 13 parts of manganese dioxide, contained in a sealed retort. The gas requires thorough washing in a solution of caustic soda to eliminate its chlorine. It can be compressed after washing in a two-stage compressor, which is the practice in one of the Davis-Bournonville oxygen plants, or generated under pressure by using heavier retorts and heating longer or more intensely. The Oxi-Carbi Company, the Henderson-Willis Welding & Cutting Company and others furnish equipment of the latter type, as well as the Delcampe Welding Company which gives the name Oxivite to the mixture used, which is claimed to give off no chlorine.

47 A somewhat similar process is that using oxygenite, the trade name for a mixture of perchlorate of potash with infusorial earth and charcoal. When ignited in a closed retort it burns, evolving an excess of oxygen over that required for its own combustion. The reaction under the influence of heat is $KClO_4 = KCl + 2O$. The necessary pressure is obtained without subsequent compression.

48 The fault with most chemical processes is the difficulty of eliminating the poisonous chlorine, which also has a tendency to impair the weld. With all processes using manganese dioxide precautions are necessary for obtaining pure oxide, as carbon or hydrocarbons in any form, even traces of oil from a compressor which should therefore not have cylinder lubrication, must be eliminated before compressing the oxygen on account of their combustibility.

49 The purer the oxygen the better, as even small percentages of impurities decrease the economy and the strength of the welds. Oxygen produced by the electrolytic process is 99 per cent pure, the only impurity being a trace of hydrogen. The electrolytic process of the American Oxyhydric Company has already been referred to, and the principle in all is alike. Apparatus for this process is also made by the International Oxygen Company and the Davis-Bournonville Company.

50 The International Oxygen Company's system makes use of a group of oxy-hydrogen generators, each an electrolytic cell through which, by the passing of an electric current, water containing some alkali is decomposed. The oxygen collects at the positive electrode and the hydrogen at the negative electrode, which is the iron tank containing the solution. The positive electrode is a perforated tank surrounded with an asbestos sack. The two gases as they collect on their respective electrodes are effectively separated, and the bubbles

rising as they collect are entrapped in compartments at the top, separated from one another by a water seal.

51 Atmospheric oxygen is next in purity to electrolytic, its only impurity being nitrogen. The process used by the Linde Air Products Company at its various works from which it distributes for sale the gas compressed in tanks, consists first in the complete liquefaction of the air to be resolved by a process of accumulative cooling. The liquid thus formed is then submitted to a process of rectification at the same time that an almost complete transference of heat is obtained from the compressed air entering the apparatus to the liquid air thus formed. In this way 95 or 96 per cent pure oxygen can be obtained. Air is compressed by a four-stage compressor with practically adiabatic compression, and after each stage the heat of compression is removed by passing the air through a cooler, through which water is circulated. The carbon dioxide and moisture in the air are readily eliminated by freezing and the oxygen becomes liquid while the nitrogen is still gaseous. This explains in brief the principle of the separation without going further into the details of the apparatus. The equipment is in duplicate to permit continuous working, so that when ice, due to entrapped moisture, has accumulated in one the other can be put in operation while the first is alowed to thaw.

52 Another atmospheric process, partly chemical, employs barium oxide first to absorb and then liberate oxygen. With a constant pressure barium oxide will absorb oxygen from the air to form the peroxide at a temperature of 600 deg. cent. and at 850 deg. cent. will again give off the excess oxygen. With a constant temperature of 700 deg. cent. the same effects can be accomplished by varying the pressure, the peroxide being formed at $1\frac{3}{4}$ atmospheres and the excess oxygen liberated by diminishing the pressure.

PRESSURE REGULATION

53 An important device between the torch and the source of the gas, whether oxygen, acetylene or hydrogen, and whether from pipe line, generator or tank, is the pressure regulator, for with all torches it is necessary to maintain constant pressures to secure uniform work. Regulators vary somewhat according to the gas, and in minor details in different makes. The function of the regulator is that of a reducing valve to maintain any set constant pressure not exceeding that of the source, and there is always combined with it a pressure gage on the discharge side to show the pressure admitted to the torch.

Where the gas is taken from portable cylinders an additional gage is provided on the other side of the regulator to show the state of depletion of the compressed gas in the cylinder.

USE OF THE TORCH

54 The rest of this paper applies practically to all kinds of gas torches, and especially to the oxy-acetylene and oxy-hydrogen torches, unless an exception is noted.

55 The utility of all torches lies in their ability on account of the high temperatures of their flames, to bring the part of the metal acted upon to molten condition before the heat supplied can be dissipated by conduction and radiation, therefore making possible local recasting. Some heat is of course lost, but probably not without an advantage in reducing trouble from expansion and contraction.

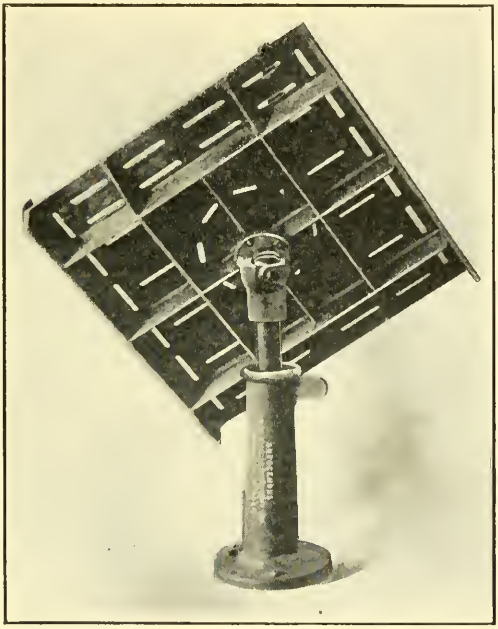

Fig. 11 Welding Table

56 The envelope of the flame starts the heating of the metal in advance of the actual work and the local heat at the point of the inner cone follows. Metal, thicker than $\frac{1}{8}$ in., to be joined should be scarfed or chamfered to give a V-groove in which to work, permitting

penetration of the flame to the bottom of the joint. It is usually necessary, except on thin sheets not scarfed, to add metal to the joint. This is melted in from a wire or strip generally of the same material as those being joined, which is called a soldering or welding stick. In making the weld, after the metal adjoining the joint is itself in running condition, molten metal is added drop by drop from the stick until the groove is filled, and where it is allowable a little excess is built on to make the joint fully as strong as the rest of the work. If the metals joined are dissimilar, a stick of approximately the same material as that of the two being joined which melts at the lower temperature should be used. Otherwise the added metal will chill when falling upon the other molten metal. Scaling powders are sometimes used for welding cast iron and aluminum, but less so than formerly since experience has shown them to be seldom necessary. The function of a scaling powder is not primarily that of a flux to prevent oxidation, but to remove any scale in the weld and make the metal more fluid. With proper manipulation of the torch, which is now better understood, scale is not so apt to be formed in the first place.

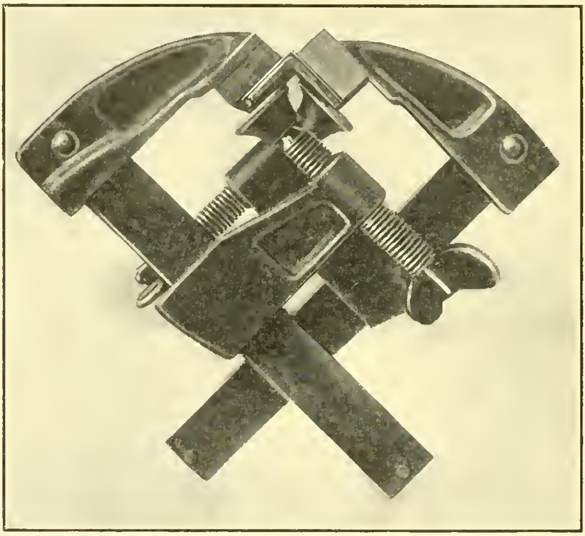

Fig. 12 Clamping Arrangement for Welding Two Thin Pieces

57 A torch or nozzle is selected which will give a size of flame suitable for the work in hand, which must be large enough to do the work

thoroughly in the shortest time without consuming unnecessarily large quantities of the gases. With the proper blowpipe flame the heat is kept local so that expansion and contraction influences are minimized. It is not good practice to hold or grip anything to be welded so that it cannot adjust itself for expansion and contraction. Therefore, long seams, longitudinal or circumferential, should be first spot-welded or tacked at intervals of 6 to 12 in., and after tacking all bands should be removed. Castings to be welded should be preheated all over if there is any chance of having contraction strains produced when the weld cools. The preheating should not go above 500 deg. fahr. if there is any serious consequence from permanently distorting the casting. The preheating, usually done in a forge, or a coke fire, or by a gas-air blowpipe, saves the corresponding application of heat with the torch using more expensive gases, and also saves the latter when the welding is being done, by reducing the loss of heat by conduction and radiation.

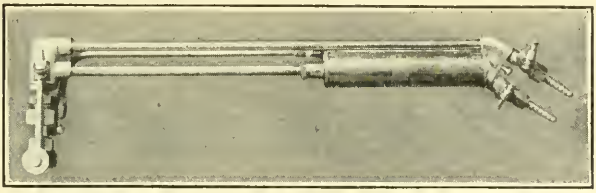

Fig. 13 Cutting Torch Showing Torch-Guiding Device

58 The welding of aluminum is something of an art in itself. This metal does not behave like any other. It first becomes pasty when heat is applied and does not become fluid until very near the burning point. It is quite common to facilitate the uniting of the metal by working it with an iron spatula until the joining parts amalgamate. Fluxes are often used for aluminum welding, the functions of which are to reduce the invisible oxide film always present on the surface of metallic aluminum, so that the parts flow together, and to protect the hot metal from the air and further oxidation.

59 Very thin metals are most easily welded when the weld is performed on the edges turned up as flanges back to back, but this is not necessary and those expert at the work can now butt-weld thin sections without even adding metal from a stick. Most depends on moving the torch steadily at the proper speed, for it is very easy to let the torch dwell too long at one spot and burn a hole through so that metal has to be added and a less neat joint results.

60 In all welding judgment plays a large part, and a knowledge of metals and their characteristics is a great help. It is a nice determination, for example, as to just how far on each side of the joint to carry the heating, since an error either way is likely to produce a poor weld. Expansion and contraction must always be taken into consideration, otherwise internal strains will occur, which are likely to produce a new crack when the metal cools. Preheating, as before explained, removes most of the difficulty.

61 As to the strength of welds, much depends upon the operator. Welded steel work can easily compare with double riveting and calking and in some cases can attain the strength of the butt strap joint.

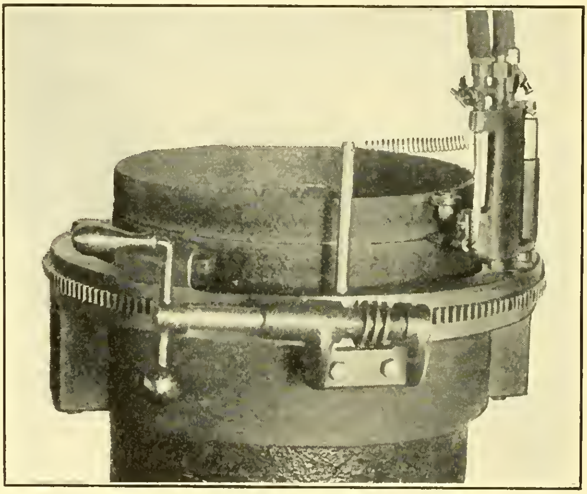

Fig. 14 Torch-Guiding Device for Circumferential Cutting

62 With flame welding nearly all kinds of metals can be welded, cast or wrought iron, steel, brass, aluminum, copper, etc. Skill and experience count for much and many things originally thought impossible are now being quite readily accomplished. A consistent study of materials and their composition and structure has led to the overcoming of many difficulties. The behavior of metals under the influence of heat, particularly their expansion and contraction, requires study and allowances in making welds. Not a little progress has already been made in the heat treatment of welds after they are

made to restore largely the original properties as to structure and strength.

63 The flame processes are especially valuable in the welding of metal from No. 20 gage up to $\frac{5}{8}$ in. thick. Work that has to withstand high heat, such as boilers, annealing boxes, etc., can be satisfactorily welded, and it is probable that this method will more and more take the place of riveting, particularly since in many cases it is cheaper. All kinds of tanks, especially those designed to contain anything that would tend to eat its way around rivets, are better for being welded.

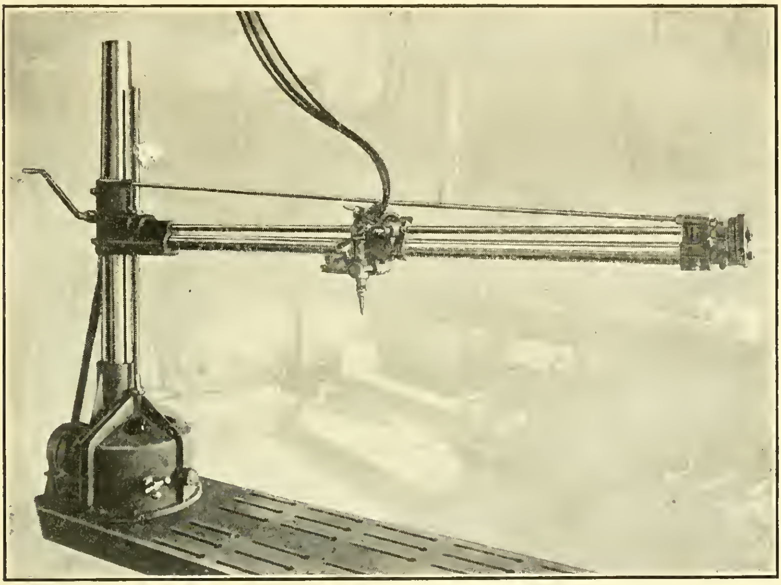

Fig. 15 Torch-Guiding Machine Capable of Swivelling to Various Angles

64 It is apart from the purpose of this paper to go into an extensive enumeration of the specific kinds of construction and repair work possible by arc and flame welding. No list would be long complete, for new applications are continually being found, and the more usual ones are already familiar to all. Among the things that are still difficult or impossible are the welding of very heavy sections, this being better left to thermit welding, flame welding being generally too expensive and the greater pressures of the gases necessary

to secure deep penetration being likely to produce crystallization of the work structure; brazed and galvanized articles, on account of the volatilization of the zinc, producing porous spots; and the welding of aluminum to other metals.

ARC AND FLAME CUTTING

65 Although the welding, and not the cutting of metals, is our subject, it would hardly be proper in a discussion of arc and flame welding to make no reference to the scarcely less important function of the same implements used in the cutting of steel and wrought iron. These are the only metals that can be so cut, some alloy steels being excepted. The torches using hydrogen have the advantage in the cutting of heavy sections, being able to cut to a greater depth on account of the greater penetration. With such torches cuts have been made in metal 24 in. thick, while 12 to 15 in. is the limit that has been accomplished with the oxy-acetylene torch.

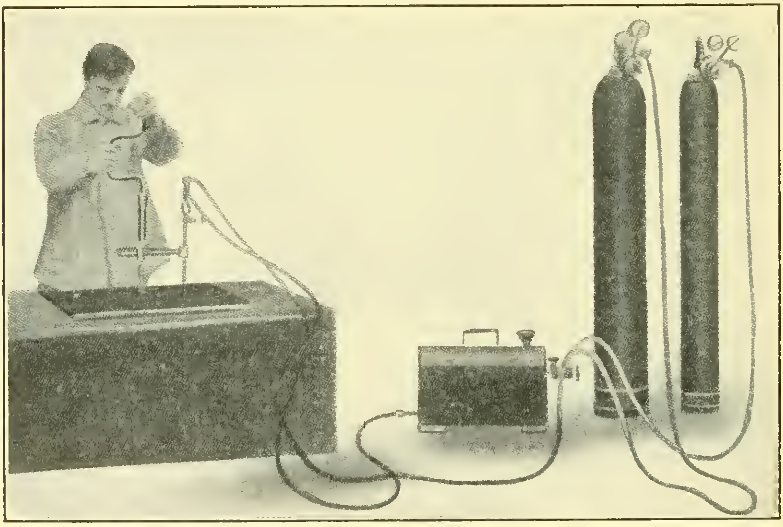

Fig. 16 Arrangement for Cutting Holes and Circles

66 For cutting, the torch has an additional jet of oxygen under higher pressure, up to 125 to 225 lb. The acetylene or hydrogen and low-pressure oxygen preheat the work, and the high-pressure jet following in the wake of the heating flame does the actual cutting by producing a very high rate of oxidation. Part of the metal is removed

as iron oxide and the heat of the combustion melts the rest so that it runs out of the cut.

67 Reference to the time and cost of doing work by any of the various processes is purposely omitted here since so many variables enter into such considerations, that any figures that might be given would probably be more misleading than instructive. Both are matters that can be determined only by experimentation under the conditions that will apply, and a result in one field can never be taken as a criterion for another.

MACHINE WELDING

68 A very large field for ingenuity has been opened in connection with all of the welding processes, in the devising of means for the mechanical guiding of the welding or cutting implements, or otherwise facilitating the operations. Most of this work has been done naturally by the users of the apparatus, particularly where the work they have to do is largely in duplicate. Unfortunately these are seldom made public, either because the user has no inclination to enter into the manufacture and marketing of them, or because he does not wish his competitors to have the advantage of their use that he enjoys.

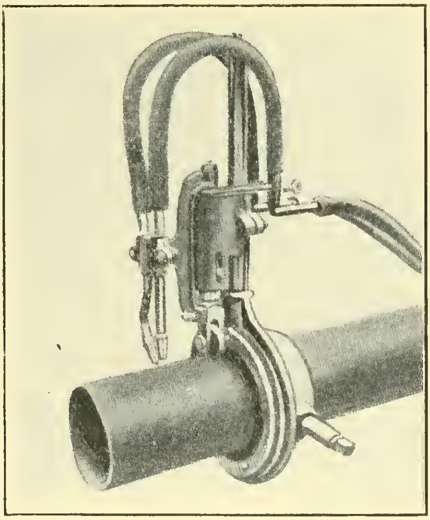

Fig. 17 Pipe-Cutting Machine

69 As indicating the scope of a few, illustrations are here included of devices or machines that can be purchased by any user.

70 Fig. 11 shows a welding table made by the Autogenous Welding Equipment Company. developed first for its own use and found so useful that it is now marketed. The work is strapped to it and can then be revolved or tilted to any position so that any part can be brought where it is most easily reached by the torch. The table can also be raised or lowered to suit the convenience of the operator.

71 Figs. 12 to 15 are Davis-Bournonville devices. Fig. 12 is a clamping arrangement for holding two thin pieces to be welded on their edges at right angles. One of the simplest of torch-guiding devices is the provision of rollers attached to the head of the torch as in Fig. 13. This happens to be a cutting torch and the rollers serve to hold the tip at the proper distance from the work. The American Oxyhydric Company has a similar arrangement. For circumferential cutting of pipes a torch guiding device is shown in Fig. 14. A more pretentious machine is that shown in Fig. 15, which will be seen to resemble a radial drill with a torch carried on the movable head where we are accustomed to see the drilling bit. It gives adjustability in all directions and a regulatable movement parallel to the arm or the column. The torch can also be swivelled to various angles. The remaining illustrations are of American oxyhydric devices. Fig. 16 is a simple arrangement for cutting holes and circles,

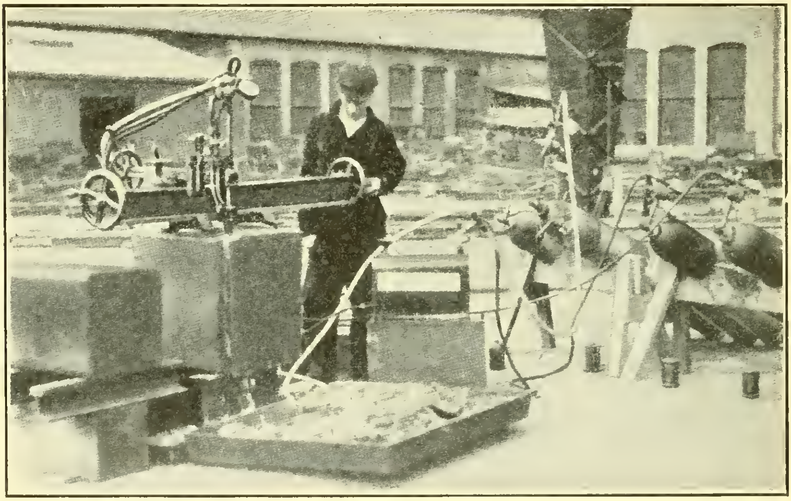

Fig. 18 Plate-Cutting Machine Finishing the Cut of a 24-in. Steel Billet

and a device is also made for cutting regular or irregular curves. Another form of pipe-cutting machine is shown in Fig. 17. Fig. 18 shows a plate-cutting machine finishing the cut of a 24-in. steel billet.

72 Attention is just beginning to be given to mechanical means for guiding the torches when doing welding and cutting. For neat uniform work of both kinds they are practically imperative, and save greatly in time that would otherwise be necessary to do careful work. With a cutting torch mechanically guided and moved at a uniform rate, circular or straight cuts can be made giving as smooth an edge as though cut by a saw or any other tool. Especially for thin sheet welding machines are desirable because of the precision with which the torch can be moved.

THERMIT WELDING

By G. E. Pellissier, New York

Associate Member of the Society

73 The compound to which the trade name thermit has been given consists of finely powdered aluminum and oxide of iron combined in such proportions and in such a manner as to react when ignited in accordance with the formula, $Fe_2O_3+2AL=AL_2O_3+2Fe$. This compound has the peculiar property that when ignited in one spot combustion proceeds throughout the entire mass without any supply of external heat, the aluminum reducing the oxide of iron practically to pure metallic iron and combining with the oxygen to form aluminum oxide or corundum. As the reaction is exothermic, an intense heat is generated, the temperature of the molten mass being estimated at about 5400 deg. fahr.

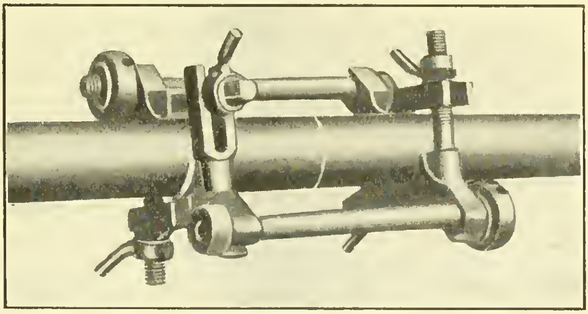

Fig. 19 Pipe Welding. Pipe held in Clamps

74 It is also of interest to note that the compound is not combustible in the ordinary sense of the word, as it can be placed upon molten iron without igniting.

75 In practice the reaction of the mass is started by a special ignition powder which creates an intense temperature at one spot, whence the reaction proceeds of itself without any further supply of

heat, requiring less than one minute for completion, regardless of the amount of the compound brought into reaction.

76 As before stated, the product of the reaction is aluminum oxide and metallic iron, the proportion being approximately 50 per cent of each by weight, but as aluminum will act similarly on the oxides of nearly all of the metals used in making steel, it is necessary only to mix these oxides with the iron oxides in correct proportions in order to obtain practically any steel that is desired.

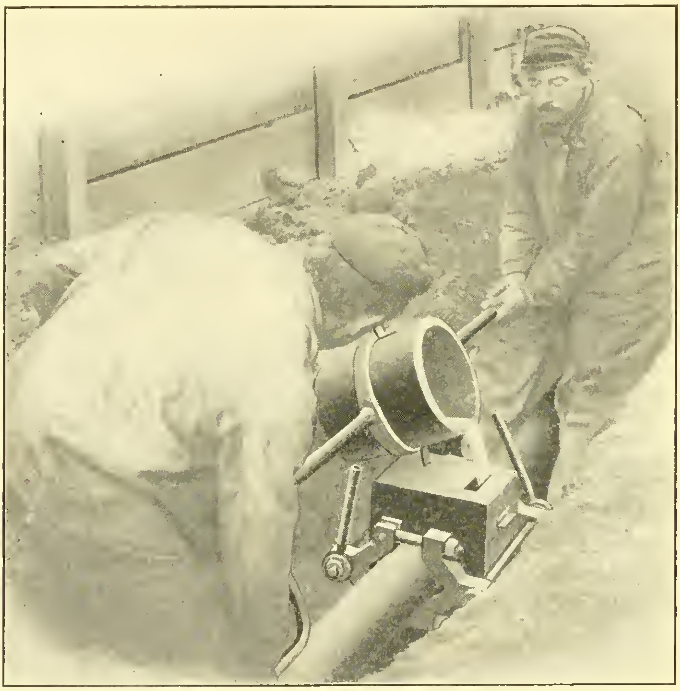

FIG. 20 PIPE WELDING IN TRENCH. POURING THERMIT SLAG AND STEEL IN MOLD

77 In applying this reaction to the problem of welding, two quite distinct methods are followed, one of which utilizes the heat of the reaction to bring the pieces to be united to a welding temperature, whence they are forced together by suitable clamps and butt-welded in a manner similar to forge-welding. In the other, the ends of the pieces to be united are fused or melted together by the molten metal from the reaction, which amalgamates with them into a molten mass,

which is retained by a suitable mold and allowed to cool, thus uniting the parts into one homogeneous mass.

78 The first method, which is commonly designated as butt-welding, is applied chiefly to welding pipes, tubes and small rods.

79 In making a weld by this method the ends of the pipe to be united are filled or machined to fit closely together, then fastened together with suitable clamps, Fig. 19, and surrounded with a cast-iron mold designed to hold just enough of the molten mass to bring the parts to be united to a welding heat. The necessary amount of thermit is then ignited in a small flat-bottom crucible, and as soon as the reaction is over the contents of the crucible are poured into the mold, Fig. 20. The aluminum oxide having risen to the top of the crucible, on account of its low specific gravity, flows into the molds first, and coming in contact with the cold iron adheres to it, forming a thin refractory coating which prevents the molten steel, which

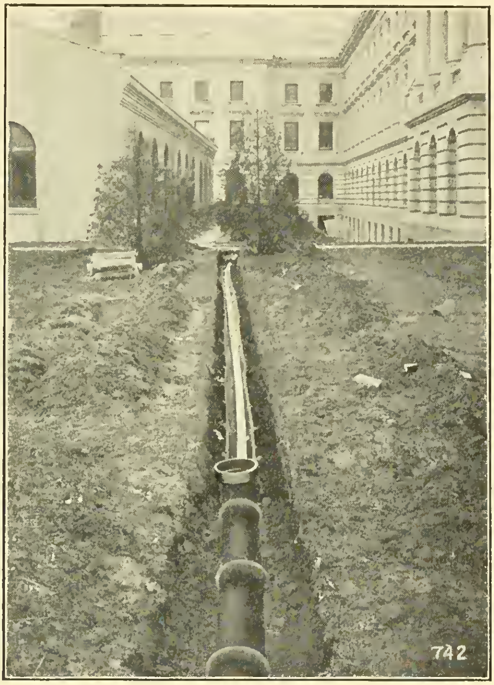

Fig. 21 Pipe Line Welded by Thermit Process for Department of Agriculture, Washington, D. C. View taken during Test. Pipes covered by Frost from Contained Ammonia

flows in later, from adhering either to the mold or the parts to be welded. As soon as the molten mass has been in the mold long enough to allow the heat to penetrate the parts to be welded, a length of time determined by experiment, the pieces are forced together by the clamps, which completes the weld. On account of the fact that pieces thus welded are heated out of contact with the air, no oxidation can take place and consequently no flux is necessary, care being taken simply to see that the parts to be united are clean and bright.

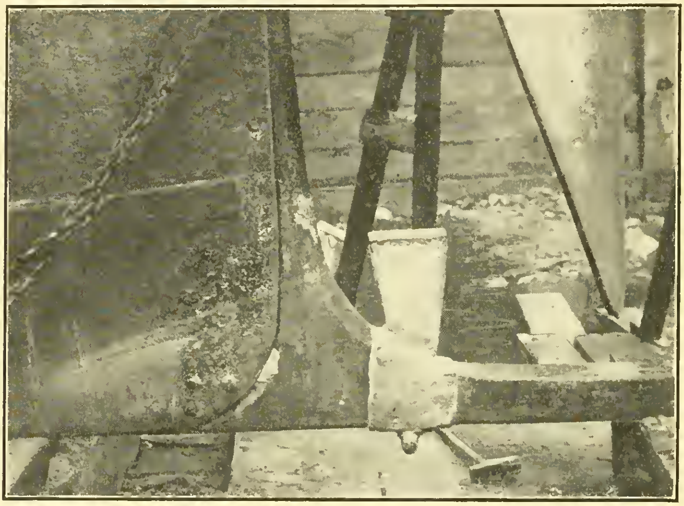

Fig. 22 Weld on Stern Frame of Steamship "Corruna" belonging to Canadian Lake Navigation Company. Weld executed in Montreal, 1907

80 Rods up to 2 in. in diameter and all sizes of pipes from 1 in. to 6 in. in diameter, standard, extra heavy and double extra heavy, have been welded by this method.

81 The chief application of this process is in welding ammonia, compressed air, high-pressure steam and hydraulic lines, where the work has to be done in place, Fig. 21. As the outfit required for welding 4-in. pipes weighs less than 100 lb. and can be manipulated in a trench wide enough for a man to stand in, lines can be welded which would otherwise have to be provided with mechanical joints.

82 As an illustration of the efficiency of welds made in this manner, it may be noted that a hydraulic pipe line, 4-in. extra heavy, welded for the New York Central Railroad at Albany, was subjected to a test pressure of 3000 lb. per sq. in. maintained for 24 hours, and

has been operating for two years under a working pressure of 1500 lb. per sq. in. with entire satisfaction. Physical tests on welded samples before the contract was awarded showed the strength of the welded section to average from 80 to 90 per cent of the strength of the pipe in tension and cross bending.

83 In welding by the second method, the so-called intermediate welding, the parts to be united are not brought close together nor fitted in any way, but instead a space varying with the section to be united from ½ in. to 2 in. in width is provided to allow a free flow of the molten thermit metal between the ends. After the parts have been thoroughly cleaned of grease, dust, etc., they are surrounded with a refractory mold very similar to that used in making steel castings. This mold is provided with a suitable pouring gate and riser, and in addition to this a gate or opening at the lowest part of the mold used for preheating.

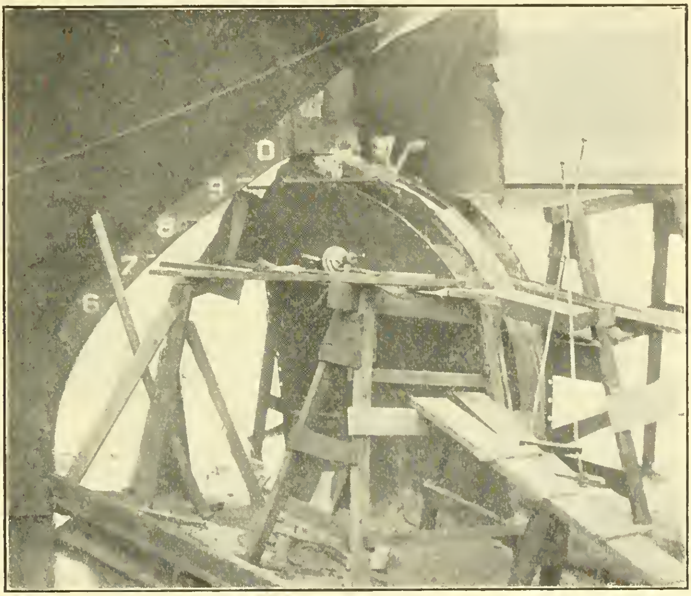

Fig. 23 Rudder Frame of Steamship "Duluth" showing Materials in Position for Welding. Repair executed without placing Vessel in Drydock

84 If the parts to be welded are of a uniform section these molds are made from wooden patterns similar to standard foundry practice; but where the parts to be united are of an irregular section which

would involve difficult and expensive pattern work, such as in repair work, the so-called wax method is used. In this method the space between the parts to be united is filled with wax and a reinforcing collar of any desired dimensions is formed of the same material. As soon as the wax is hard the parts are surrounded with a mold box and the mold rammed in place, wooden patterns being used for gates and risers. Heat is then applied through the preheating gate at the lowest part of the mold, which melts the wax, allowing it to flow out and leaving a cavity in the mold of the exact dimensions desired. The preheating is then continued until the mold is thoroughly dried and the ends of the pieces to be welded are brought to a bright red heat. While the preheating is going on, a so-called automatic crucible, having a small opening in the bottom with arrangements for pouring and tapping, is placed over the heating gate of the mold, into which are poured the thermit and additions.

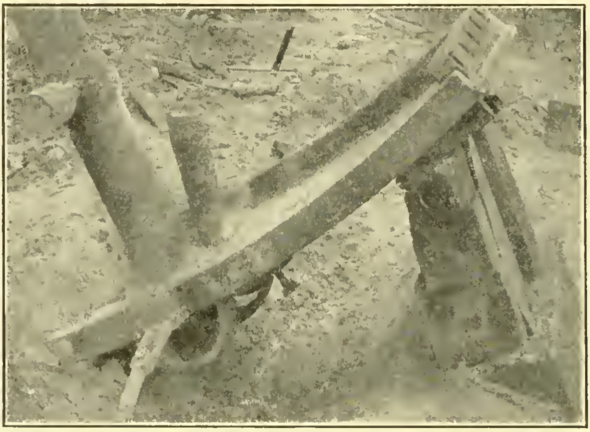

Fig. 24 Two Welds on Flywheel executed for Consolidated Nickel Company, Sylva, N. C. This Flywheel was 24 Ft. in Diameter and Welded Segment weighed 10 Tons

85 The amount of thermit necessary to fill the mold is obtained by weighing the wax used and multiplying the weight by 32. This is obtained by multiplying the weight of wax by the ratio of specific gravity of wax to that of iron, approximately, then by 2, as thermit is half iron, and again by 2 to provide for metal in the riser. To the thermit is added the proper amount of carbon steel punchings, nickel chromium, manganese, etc., to give the resulting steel approximately the same analysis as the pieces to be welded. These alloys can be

added in the form of shot or as manganese thermit, chromium thermit, etc.

86 In making welds in this manner the usual precautions have to be taken to provide for the contraction of the metal when cooling whenever possible. Welds can of course be made where it is impossible to provide for such contraction, but the welds will then be subjected to the internal stresses due to cooling. This method of welding has its chief application in welding rails for street railway companies and in repairing all kinds of machinery where the sections to be welded are large, and where the work of necessity has to be done rapidly or in place. Among such repairs might be mentioned the welding of engine frames, crankshafts, stern and rudder posts of vessels, flywheels, and large castings of every description.

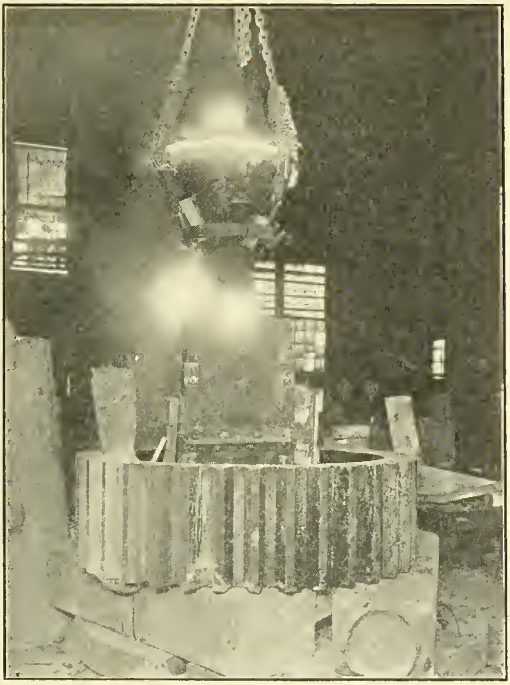

Fig. 25 Gear Wheel Welded in Two Places. View shows one Completed Weld and Thermit Steel Flowing in the Mold for Second Weld

87 A brief description of a few representative repairs will serve to illustrate what may be accomplished by this method of welding.

88 In getting away from her pier in the Lachine Canal, the "Corrunna," a vessel of 1296 tons registered, 35 ft. beam and 21 ft. depth, was caught by the current and swung against the walls of the canal, the skeg being broken off close to the keel and the rudder post 10 in. above the top of the rudder.

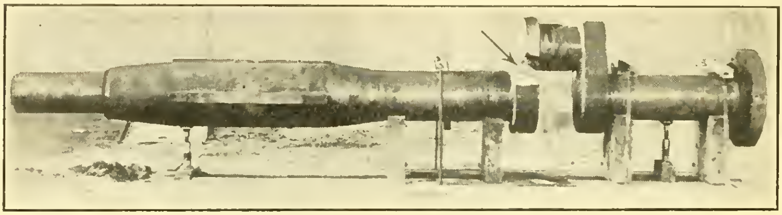

Fig. 26 Fracture in 14-In. Crankshaft of Binghamton Railway Company, Binghamton, N. Y., Cut Out for Thermit Repair

89 As there were no facilities in Montreal for making a repair of this nature, it would have been necessary to tow the vessel to Cleveland. Both of these welds were made in five working days without removing the stern frame. Fig. 22 gives a clear idea of the character of the work.

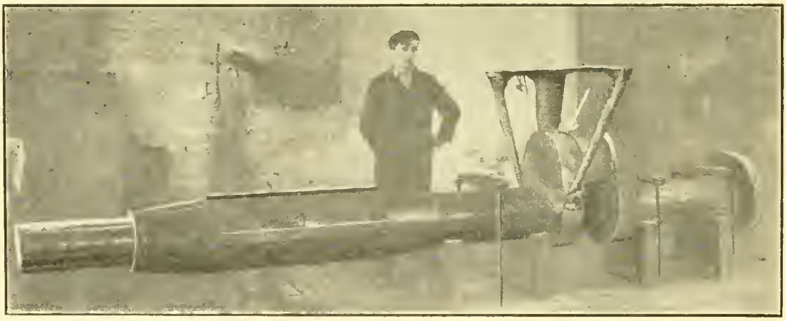

Fig. 27 Finished Weld of Binghamton Crankshaft showing Metal left in Pouring Gates and Riser. Surplus Metal removed before placing Shaft in Service

90 The steamship "Duluth," which is 404 ft. long, 50 ft. beam, and 6400 tons registered, had its rudder frame broken 10 in. aft of the rudder post, the section to be welded being $2\frac{1}{2}$ in. by $9\frac{1}{2}$ in. The work of welding was carried on without docking, rafts made fast to the vessel (see Fig. 23), and required only two days for completion.

91 A flywheel, weighing 48 tons, was wrecked at Sylva, N. C.,

when the car upon which it was being transported overturned. The wheel, which was 24 ft. in diameter, 74 in. face and weighed 48 tons, was cast in four pieces. The piece wrecked was broken through the rim, the section of the fracture being about 3½ in. by 37 in., with ribs at the edges 3½ in. by 6 in., and one of the spokes was broken near the hub and near the rim, sections at fractures being about 8 in. by 11 in. elliptical. The part repaired is shown in Fig. 24. The repair was made in the wilderness where the wreck occurred, the nearest machine shop and source of supplies being 50 miles away. The flywheel has been in continuous service over two years under severe conditions, as the 750-h.p. engine and generator of which it is a part are frequently subjected to a 50 per cent instantaneous overload.

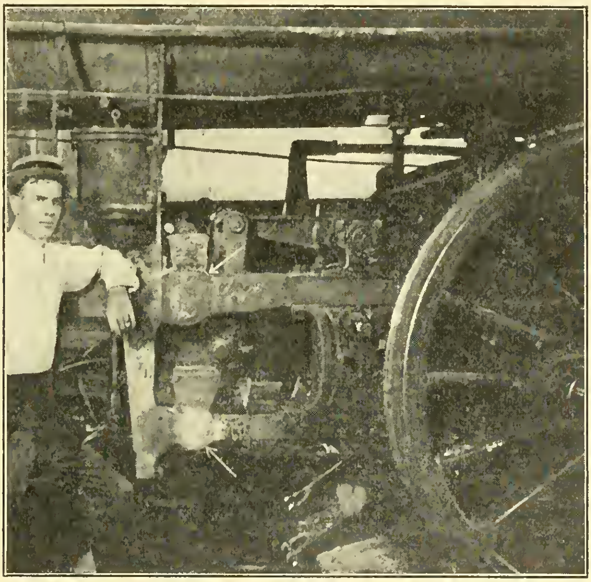

Fig. 28 Two Finished Thermit Welds on a Locomotive Frame. Repair being executed with very little Dismantling of the Locomotive

92 A steel gear driving a so-called continuous rolling mill at the works of the American Tool and Stamping Company, at Bridgeport, Conn., was broken in two places. The gear is 6 ft. in diameter with a 22 in. face. The time required for making these two repairs complete was 46 hours. Fig. 25 shows one of the welds repaired and the other being poured.

93 The main driving shaft of the 750-h.p. engine and generator

at the Binghamton Railway Light and Power Company, Binghamton, N. Y., was 15 ft. long over all and varied in diameter from 10 in. to 16 in. The crank webs, one of which was broken in two places, as shown in Fig. 26, are 28 in. by 18 in. by 6½ in. The work of welding was not done in place in this instance but at the shops of the Goldschmidt Thermit Company, as it was impossible to align the shaft properly in the power station. The welding completed ready to remove the risers is shown in Fig. 27. The operation required three days.

94 Fig. 28 shows an interesting repair to a locomotive frame, and many other illustrations might be given of the practical application of this method of welding, multiplying many times those already shown.

TABLE 2 BENDING TESTS

Description	Size of Bar, In. Diameter	Span, Ft.	Total Load, Tons	Angle Bent Through	Effects
Solid bar	2	15	10.18	180	Uncracked
Thermit welded bar, bulb turned off	2	15	10.09	46	Broken at weld
Thermit welded bar, bulb left on	2	15	17.30	125	Bent as far as practicable. Uncracked

TABLE 3 TENSION TEST

RIEHLE BROTHERS TESTING MACHINE CO., INC., PHILADELPHIA, APRIL 7, 1908

Size, In.	Area. Sq. In.	Elastic Limit, Lb.	Elastic Limit per Sq. In., Lb.	Ultimate Strain in Lb.	Ultimate Strain per Sq. In., Lb.
749	0.441	18670	42330	27930	63330

95 As regards the efficiency of welds made in this manner, the physical tests and chemical analyses in Tables 2 to 4 show clearly that the metal of the weld is practically equal in strength to the metal of the parts repaired, except possibly in the case of special steel alloys. When it is considered, however, that the section at the fracture can be increased to any desired dimension when the repair is made, it will be readily seen that the repaired section can be made stronger than it was originally.

96 The section tested in tension was taken from a weld on a section 6 in. by 8 in. and was turned from the thermit metal and not subjected to annealing or forging.

97 Table 4, giving the chemical analyses of welds made on carbon

steel and carbon steel containing nickel, illustrates how closely the material of the weld approaches that of the metal welded.

TABLE 4 CHEMICAL ANALYSES OF WELDS

	Nickel Steel					Carbon Steel			
	C	M	S	P	N	C	M	S	P
Steel	0.92	0.76	0.029	0.018	1.06	0.55	0.89	0.068	0.09
Weld	0.36	1.21	0.019	0.036	1.11	0.48	0.90	0.032	0.063

98 The process of welding is invaluable for all kinds of repair work, not only because by welding broken parts the pieces themselves can be made as good as new, thus saving the original cost, but on account of the extreme portability of the outfit and because in nearly all cases the welding can be accomplished on the spot, thus saving a great deal of time and keeping a plant or ship in operation when it would otherwise have to be put out of commission for days, weeks, and sometimes months.

ARC WELDING

By C. B. Auell,[1] East Pittsburgh, Pa.

Non-Member

99 Welding through the medium of the electric arc may be accomplished by any of three different processes, named respectively after the inventors, Benardos, Slavianoff and Zerener. Like oxy-acetylene and oxy-hydrogen welding, all of these are very properly classed as autogenous welding processes, since fusion is accomplished without pressure, simply by allowing the metals to melt, then to mix and unite as they cool. The essential difference between the processes under discussion may be briefly indicated as follows:

Benardos Process. Arc drawn between the metal to be welded which forms one terminal of an electric circuit and a carbon electrode which forms the other terminal.

Slavianoff Process. Arc drawn between the metal to be welded which forms one terminal of an electric circuit and a metal electrode which forms the other terminal.

Zerener Process. Arc drawn between two carbon electrodes, the metal to be welded being placed in contact with the arc.

BENARDOS PROCESS

100 · The Benardos process is due to Benardos and Olzewski, to whom a United States patent was granted in 1887. From this date it will be noted that the term of the patent has now expired and anyone is therefore at liberty to make use of it.

APPARATUS REQUIRED

101 A complete outfit for this process of welding includes a suitable source of direct current supply, controlling apparatus for the regulation of current and voltage, carbon electrodes, a suitable enclosure for the work, a protective covering for the operator, fire-clay or other material for molding purposes, filler and flux. Fig. 29 is a diagrammatic sketch of the electric apparatus as it is perhaps most commonly used. Starting from the generator, one branch of the circuit leads through an ammeter and a circuit-breaker direct to the carbon electrode, which usually forms the negative terminal; the

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[1] Asst. Mgr. of Wks., Westinghouse Elec. & Mfg. Co.

other branch of the circuit leads from the generator, through a single-pole switch, to the main rheostat, then to the metal to be welded which, either directly or indirectly through a metal table, forms the other terminal. There are, of course, modifications of this general scheme, each of which possesses one or more features of merit, but the limits of this paper preclude their being discussed in detail.

CURRENT SUPPLY

102 The current, which must always be direct, may be obtained in any of several ways: (*a*) from an independent generator, shunt or

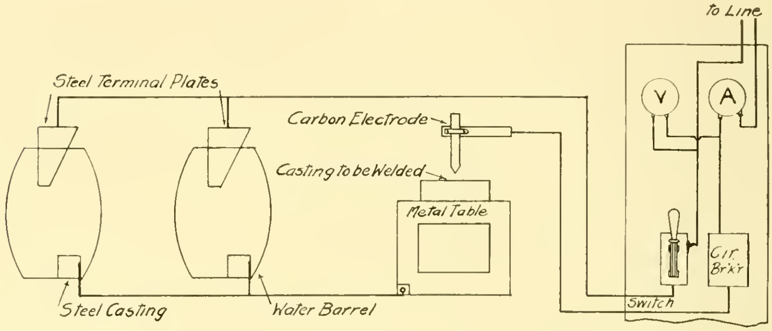

FIG. 29 DIAGRAMMATIC SKETCH OF ELECTRIC APPARATUS. BENARDOS PROCESS

compound, of at least 15 kw. capacity, preferably larger, at 75 to 100 volts, and either belt or direct driven; (*b*) from public supply mains of like voltage and capacity; (*c*) from a battery operating in conjunction with either (*a*) or (*b*). As intimated, current may also be obtained from a higher voltage than that specified, if it is the only kind at hand, resistance being then introduced into the circuit to cut down the voltage to the required amount. This, of course, is wasteful and is recommended only where the welding to be done is so small in amount or of such infrequent occurrence as not to warrant a proper installation. Fig. 30 shows a 200-kw. motor generator, with the motor and generator connected by means of a flexible coupling, but except for the room required a belt-driven outfit could be used equally well.

CONTROLLER APPARATUS

103 Different current strengths are required for different sizes of welds, and means must accordingly be available for regulating the current supply. This is usually effected by inserting a variable resistance in the main current, though in the case of a suitable gen-

erator its field may be weakened instead and the same result accomplished. In the diagrammatic sketch, Fig. 29, the resistance consists of two water barrels arranged in parallel. Pulleys and counterweights are provided by means of which the distance between the terminal plate at the top of each barrel and the steel casting at the bottom may be altered at will and the resistance increased or diminished proportionately. The objection to water barrels is that when the plant is worked hard the water will boil over, thus requiring a stoppage of the work in order to allow the water to cool. The overflowing of the water further causes the hoops on the barrels to rust, which in turn makes necessary the replacing of the barrels from time to time. Again, a spark may occasionally drop into one of the barrels, producing a loud explosion, without damage, however, other than startling the operator. This explosion is due apparently to an accumulation of a small amount of oxygen and hydrogen from the electrical decomposition of the water. For these several reasons it is preferable to use grids instead. Fig. 31 shows the water-barrel device referred to.

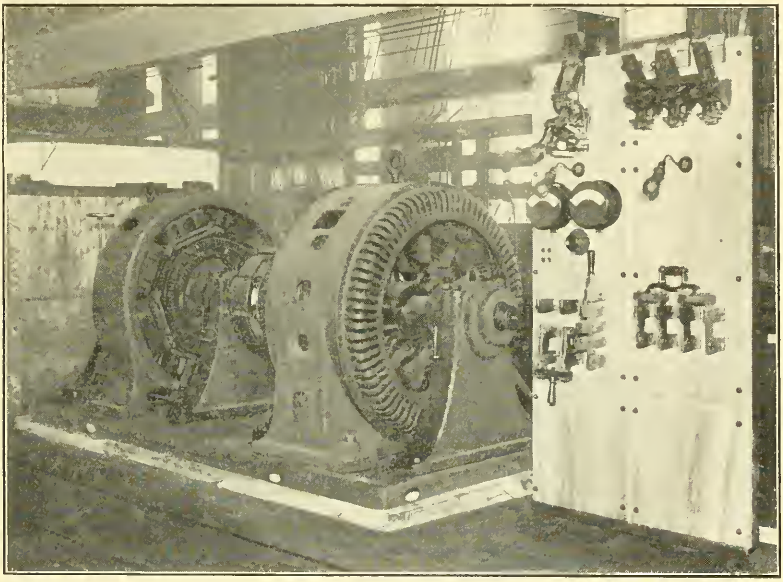

Fig. 30 200-Kw. Motor Generator Outfit

ELECTRODES

104 The type of electrode used is illustrated in Fig. 32. It con-

sists of a piece of pipe threaded as shown, and provided with a wooden handle having an asbestos or fiber guard. Into one end of this handle is inserted and clamped the carbon, which in turn is held by pressure in a suitable metal eyepiece. The carbons as a rule are from $\frac{3}{4}$ in. to 1 in. in diameter and 6 in. in length. They should be hard and solid (uncored), of graphite, not of coke, and in burning away should leave a rounded end instead of a pencil point.

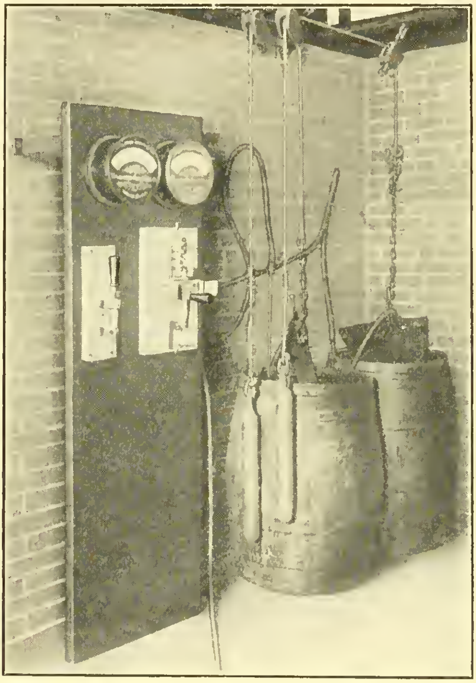

FIG. 31 WATER-BARREL DEVICE

ENCLOSURE FOR WORK AND PROTECTIVE COVERING FOR OPERATOR

105 Owing to the intense brightness of the arc the welding must be done in an enclosure, otherwise it would seriously interfere with any other work in the vicinity. It is further necessary to protect the operator thoroughly, as the rays of the arc cause an irritation of the skin much like sunburn, even where the exposure has been of but a few minutes' duration. No more serious consequences ensue, however, and at the expiration of a couple of days all traces of the burn disappear. The clothing is sufficient protection for the body; for the

hands and wrists, gauntlet gloves of pigskin, or even of heavy cotton duck will suffice, while for the head a hood made of canvas, wood or stovepipe, and fitted with a small projecting window of colored glass, is usually worn, Fig. 33. Sometimes the operator prefers to use a wooden shield fitted with colored glass, which is held in one hand. There is some slight objection to the canvas hood, owing to the lack of ventilation; the stovepipe overcomes this objection, but there is the possibility of receiving an occasional shock in wearing it, due to the carbon electrode being brought accidently into contact with it. The wooden helmet has neither of these objections, though it is rather an awkward piece of wearing apparel. Any type of headgear has an appreciable advantage over the hand shield, in that both hands are left free. The window should consist of several thicknesses of glass, red and blue, or red and green, the combination being rather more satisfactory than a single color. The window of the headgear must be made to project an inch or so, for the glass eventually becomes rather hot, and if too close to the eyes will tend to inflame them. In the operation of welding some fumes are given off, but as these are not sufficient to cause any difficulty no special provision need be made to take care of them.

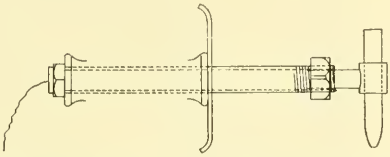

Fig. 32 Type of Electrode Used in Benardos Process

FILLER AND FLUX

106 When welding steel and wrought iron the filler may be soft Norway or Swedish iron, trimmings from boiler-plate, bits of broken steel castings, or the like; for cast and malleable iron, besides any of the preceding, it is permissible to use copper wire or rods of special cast iron which is high in silicon.

107 While flux is not necessary, as a rule, in the welding of steel or wrought iron, it is, however, frequently used in connection with cast and malleable iron, and numerous patents have been taken out along this line. A flux considered very good by many practical welders consists of red oxide of iron (Fe_2O_3), 15 to 25 per cent; borax pulverized ($Na_2Bo_4O_7+5H_2O$), 85 to 75 per cent. Another flux con-

sists of oxide of copper (CuO), 5 per cent; oxide of manganese (MnO_2), 15 per cent; red oxide of iron (Fe_2O_3), 30 per cent; borax pulverized ($Na_2Bo_4O_7+5H_2O$), 50 per cent.

108 These fluxes may be used either dry or wet. If wet they are shaken directly into the weld a little at a time as it is undergoing formation; if dry, a paste is made and the filler rod coated with it and allowed to dry before using.

MAKING THE WELD

109 In making the weld the piece to be welded may be laid upon the metal table, shown diagrammatically in Fig. 29, being thus indirectly connected to one terminal of the conduit, or the terminal may, if preferred, be connected directly to it, as in Fig. 33, where no table is used. The resistance in the circuit must next be adjusted for the proper flow of current. The circuit breaker and finally the single-pole switch are then closed, after which the operator takes the carbon electrode in one hand, and has the filler and flux within convenient reach of the other. The hood or helmet, if a hand shield is not used, is then pulled down over the face, and the arc struck by bringing the electrode into contact with the metal and instantly withdrawing it at least three-quarters of an inch. Many operators prefer a still longer arc, as the heating

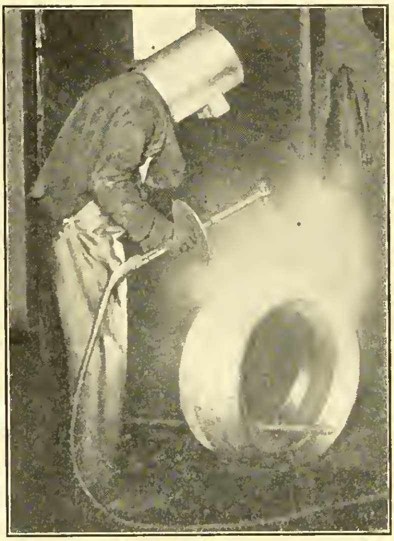

Fig. 33 Protective Covering for Operator Used in Arc Welding

effect is more regular and better distributed; there is, moreover, less chance of particles of carbon entering the weld and making it hard.

110 If the arc is too fierce or if it goes out too frequently the resistance should be increased or decreased accordingly. Assuming, however, a satisfactory condition, the electrode is given a slow rotating motion, thus causing the arc to heat a larger area than otherwise and to assist in a better distribution of the molten metal. A little of the filling material is added from time to time, the arc meanwhile being continued, if possible, without interruption. When the weld is made, and while still hot, it should be thoroughly hammered to eliminate sponginess from the metal, as well as to give it a finer grain. All impurities must be kept from the weld, and the metal should further be perfectly clean before proceeding with the work. This last is accomplished either by chiseling or by tilting the piece to such an angle that when the arc is applied the molten slag will run off by gravity. The piece may then be righted and the welding commenced.

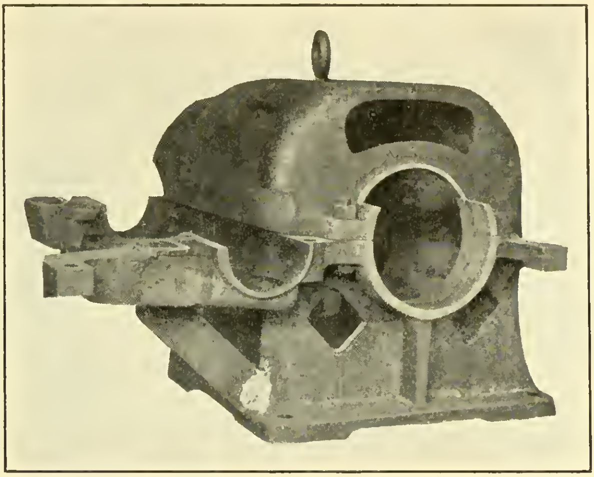

Fig. 34 Steel Casting Received from the Foundry

111 Fig. 34 shows a steel casting received from the foundry minus the piece supporting the rear axle bracket. This defect was readily remedied on a lot of 10 such castings by welding on a wrought-iron bar of the proper dimensions. Fig. 35 shows a steel axle cap before and after welding on one new lug and refilling the other.

112 Occasionally it may be necessary, as in the case of certain iron

castings, to preheat the piece if cracks are to be avoided. This may be done by means of a gas torch turned directly upon the casting; or a small furnace may be built around the piece by means of fire bricks and a gas jet introduced. In the latter case, when the piece reaches a dull red color, the gas is shut off, several bricks in the vicinity of the proposed weld are removed and the weld made. The bricks are then replaced and the casting allowed to cool off gradually and uniformly.

OTHER USES OF THE BENARDOS PROCESS

113 Besides welding, the Benardos process may be used quite advantageously in other ways, as in the removal of sink-heads from steel castings, the opening of tap holes and tuyeres in furnaces, the boring of holes in iron plates, the cutting up of steel and wrought-iron scrap, etc.

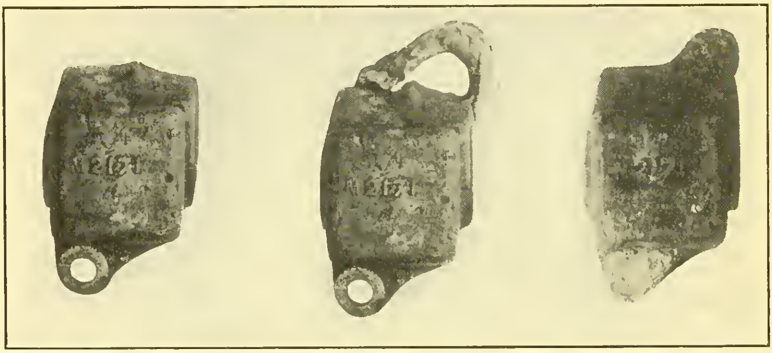

FIG. 35 STEEL AXLE CAP BEFORE AND AFTER WELDING ON ONE NEW LUG AND REFILLING THE OTHER

114 From the nature of the work it will be evident that the compilation of reliable data as to current consumption, strengths of welds, costs, etc., is an exceedingly difficult matter. Nevertheless, certain items may be given for those who are interested in the subject, more however as a guide rather than as representing any especially remarkable performances.

115 Perhaps the most complete published statistics regarding the strengths of welds are contained in a pamphlet published by Messrs. Lloyd and Lloyd of Birmingham, England, the tests (Table 5) being undertaken for them by Mr. Henry Lea of Birmingham, working in conjunction with Messrs. David Kirkaldy and Son of London. These results are excellent, but would seem to be considerably higher than

TABLE 5 MEAN RESULTS OF TESTS OF FIRE-WELDED BARS COMPARED WITH ELECTRIC-WELDED

Brand [1]		Size, In.	Ultimate Tensile Strength per Sq. In. in, Tons of 2240 Lb.	Contraction of Area at Fracture, Per Cent	Extension in 10 In., Per Cent	Ratio of Weld to Solid, Per Cent
Low Moor Iron	F	2 x 3/16	20.3	15.2	7.3	77.9
	E		21.1	17.3	7.3	81.1
Low Moor Iron	F	2 x 5/16	21.5	22.3	11.3	90.7
	E		21.8	20.7	9.7	91.8
Netherton Best Iron	F	2 x 1/4	18.4	10.1	3.4	84.4
	E		20.1	10.8	4.5	92.0
Parkgate Steel	F	2 x 1/8	20.9	9.3	1.9	69.1
	E		22.3	18.4	3.8	73.6
Parkgate Steel	F	2 x 1/2	20.4	15.9	8.1	82.3
	E		21.0	15.4	7.3	86.4

[1] F = Fire-Welded. E = Electric Welded.

TABLE 6 LABOR COSTS OF BLACKSMITH VERSUS ARC-WELDED RINGS

Rings		Smith-Welded	Arc (Carbon)-Welded
Section	Inside Diameter		
1¼ x 1½	2 ft., 11⅞ in.	$0.66	$0.30
1½ x 2	4 ft., ¼ in.	1.13	0.45
1¾ x 2½	5 ft., ¼ in.	1.25	0.45
2 x 6	4 ft., 4 3/16 in.	3.05	0.85

TABLE 7 BENARDOS PROCESS. FILLING CAVITY

Line Volts	Arc Volts	Amperes	Diameter of Carbon, In.	Length of Arc
77	43	160	1	¾ to 1
77	42	160	1	¾ to 1
77	45	156	1	¾ to 1

TABLE 8 BENARDOS PROCESS. CUTTING OFF CAST-STEEL SINK HEAD (2⅜ IN. x 5½ IN.)

Line Volts	Arc Volts	Amperes	Diameter of Carbon, In.	Length of Arc, In.	Time Required, Min.
75	47	640	1¼	1½ to 2	4 1-5
75	53	560	1¼	1½ to 2	4 1-5
75	46	760	1¼	1½ to 2	4 1-5
75	52	680	1¼	1½ to 2	4 1-5
75	50	650	1¼	1½ to 2	4 1-5
75	51	720	1¼	1½ to 2	4 1-5

should be counted on in ordinary practice. It must be borne in mind, however, that very frequently the material may be thickened or built up in excess of the original dimensions at the weld, thus increasing the strength to a point not otherwise obtainable.

116 A comparison of the labor costs of blacksmith and arc-welded rings is given in Table 6, while in Tables 7 and 8 the current consumption, etc., for various kinds of work are shown.

117 The greatest criticism which may be made of the use of the Benardos process is that apparently, in spite of the best care, the results obtained are not always uniform, the welds being occasionally hard. Where, however, no machining enters in, this is not a serious matter; in fact, hardness may prove at times an especially valuable feature, as in the repair of bending rolls. If directions have been carefully followed and hard welds are still obtained, the only solution is either to anneal or to remake them.

TABLE 9 SALVIANOFF PROCESS. LAP WELDING $\frac{3}{16}$ IN. STEEL PLATES ON EDGES

Line Volts	Arc Volts	Amperes	Diameter of Electrode, In. Iron	Length of Arc
50	20	160	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
50	24	140	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
50	24	140	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
50	23	150	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
51	20	160	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
51	24	140	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
58	32	180	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$
58	22	162	$\frac{1}{4}$	$\frac{1}{8}$ to $\frac{1}{4}$

TABLE 10 DATA ON STRENGTH OF WELDS

	Breadth, In.	Width, In.	Area, In.	Ultimate Tensile Strength in Tons of 2240 Lb.		Extension in 4 In., Per Cent	Cold Bend, Deg.
				Total	Per Sq. In.		
Unannealed	1.0	0.56	0.56	15.3	27.4	12	58
Annealed	1.0	0.55	0.55	14.5	26.3	14	160

SLAVIANOFF PROCESS

118 In an endeavor to surmount the difficulty of hard welds, Slavianoff modified the Benardos process by substituting a metal electrode for the carbon, the electrode being usually of the same material as the piece undergoing welding. While in general the process is the same as the Benardos, there are certain details which

require close attention. In the welding of iron or steel the electrode should be of the best soft iron wire, $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in diameter by about 12 in. in length, and the current approximately 125 to 175 amperes at 25 to 30 volts across the arc; the arc itself will not as a rule be over $\frac{1}{8}$ or $\frac{3}{16}$ in. in length, instead of 1 in. or so, as in the Benardos process. Of course, these items will vary within certain limits from the figures given, depending upon the size of the work, which must be carefully studied. A considerable amount of skill is required in the manipulation of the electrode, because of a tendency to stick to the metal when contact is made as the arc is struck. The temperature of the electrode and of the piece in the vicinity of the weld should, if possible, be the same; in other words, both should be melted in order to make a true weld. It is perhaps more frequently the custom to make the metal electrode the positive terminal, while in the Benardos process the reverse is usually true. Certain data as to current, etc., are given in Table 9.

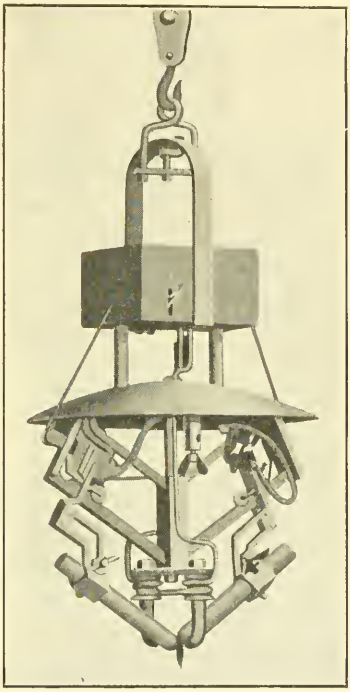

Fig. 36 Form of Apparatus for Zerener Process

119 The Slavianoff process is used for all welding where strength

is of prime importance, and is in such cases much to be preferred to the Benardos process. It will, of course, be evident from the details given that the volume of work will be considerably less in the same period of time.

120 Regarding the strengths of welds made by this process, Mr. H. Ruck-Keene, in a paper read before the Institution of Marine Engineers, England, gives the data shown in Table 10.

ZERENER PROCESS

121 The Zerener process is apparently not used in this country, and but to a limited extent abroad. Fig. 36, taken from Glaser's Annalen, 1907, illustrates one form of the apparatus which resembles in some respects certain types of arc lamps. The arc is drawn between two inclined carbons and is directed downwards into a pencil point by means of an electro-magnet, the piece to be welded being brought under the influence of the flame and thus raised to the required temperature. The construction of the apparatus and the difficulty of obtaining close regulation of the arc would seem to preclude the use of this process to any large extent.

CONCLUSION

122 Arc welding by the Benardos process covers a field entirely its own which cannot be infringed upon with advantage by any other process. It is unequaled both in cost and speed for large work of the rougher kind and where appearance or finish and strength are not of paramount importance. Where the last item is an essential, the Slavianoff process is to be preferred.

123 Compared with welding either by oxy-acetylene or by oxy-hydrogen, it is the opinion of the writer that both of these gas processes have the advantage over the electric arc processes in the matter of average strengths of welds, as well as in smoothness of finish; but as regards cost and speed the advantage, as stated above, would seem to be the other way.

DISCUSSION ON WELDING

Following the presentation of the preceding papers, there was a general discussion by a number of engineers in attendance at the meeting, from the minutes of which the following brief abstracts and notes are taken[1]:

The electrical resistance process was referred to by W. H. Brown, who explained the action of the common spot welder and of a new type in which the magnetic field is eliminated and the copper losses are reduced to nothing. W. H. Spire[2], continuing on the same subject, stated that his company was making butt welds mainly, and had made welds in almost all kinds of materials. The process had been developed to a point where welds were made in material $\frac{5}{8}$ in. thick, about 2000 welds a day for one man. High-speed steel and machine steel were welded and the results were satisfactory if the material was properly heat-treated afterwards.

W. J. Fritz[3] gave an interesting account of the work done by his company upon the wreckage of the battleship Maine by the aid of the oxy-acetylene blowpipe. The work could have been done only by this or some similar process, or by the use of dynamite, to which there was serious objection—the authorities did not like to blow to pieces the remains of the poor fellows who were entrapped in the wreck.

The thinner metal, up to $\frac{1}{2}$ in. thick, in many cases was so badly corroded that it often required only a few blows from a mechanic's hammer to break it entirely in two. The heavier beams, the boat davits and boat cradles, etc., and protected deck, had to be cut away by oxy-acetylene.

The largest job undertaken while the demonstrator was there was the cutting of the conning tower tube, which consisted of hollow steel, 2 ft. external diameter and 5 in. thick. The operator worked under unusual difficulties, since it was impossible to get into a position where he could watch the cutting action and see what was going on. The tube was cut off in about 50 minutes.

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[1] Complete discussion may be consulted in the Library of the Society.

[2] Electric Welding Products Company, Cleveland, Ohio.

[3] Linde Air Products Company, New York.

A great deal of the steel that had to be cut was backed by the wood of the deck. There was no place for the slag or iron oxide to run through and the wood had become quite decomposed in the water, making it a rather difficult piece of work all the way through. The difficulties encountered can better be understood when the terrific force of the explosion and consequent distortion of the structural members is comprehended. This is shown by the fact that the starboard turret, of steel 12 in. thick, and containing two 10-in. guns, was blown such a distance from the wreck that it has not yet been located.

The question was raised at the meeting as to the strength of welds and the danger of the metal being weakened by burning. J. F. Springer [1] said there were two methods of strengthening the steel, one by increasing the amount of metal in the weld and the other by restoring the steel by an annealing process. The chairman pointed out that there is very little danger of the flame affecting the strength unless it is left alongside the metal. The advantage of a high flame is that it brings the metal to a welding heat in a short time. Also, the envelope of the flame protects the work it blows on, keeping out the oxygen of the air; and with chemical actions going on inside, such oxygen as is present is being taken up and the metal does not burn. It was further suggested that the mere question of temperature at which a workman carried on the operation was not so important, except as a high temperature came in combination with an excess of oxygen or carbon. A point that should be considered is that the welding process produces in the weld a structure which corresponds to cast metal in combination with metal which perhaps is rolled or hammered, or has been through some of the other processes of manufacture. While the character of the metal in the weld can be restored by further working and hammering, anything of that kind is necessarily imperfectly done and introduces uncertainty as to the ultimate strength of the metal.

W. H. Spire stated that in electric welding processes, the resistance method, his company did not guarantee any welds of carbon steel higher than 25-point, unless they were annealed, and it was found of advantage to heat-treat the steel after welding, restoring the metal in the weld and giving it a sort of ironing out.

G. E. Pellissier stated that if it was desired to get nearly the strength of the original metal it would seem necessary to pre-heat it.

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[1] 608 W. 140th St., New York.

Even though the metal in the weld were sufficiently strong, the line of demarkation between the cold metal and the molten metal is so sharp there would be a point somewhere at which the strength would not be so great. It had been found of great advantage to preheat so as to divert the heat from the center of the weld back some considerable distance, making the change in the metal from the welded point as gradual as possible, instead of abruptly. It requires much less gas or thermit or any other heat to do the welding if preheating is resorted to.

T. S. Tenney referred to the German practice of welding steam piping for both high-pressure and low-pressure work, and asked to what extent it had been done in this country. Harry Harbison[1] replied that much of the high-pressure work which was formerly made up of short lengths is now made altogether of steel pipe, and where branches come out of the main line, instead of using a casting, a hole is cut and a piece of pipe set in and welded by the autogenous process. He referred to an 18-in. header, 36 ft. long, in one piece, with 10 branches, welded for high-pressure superheated steam work. There had been no complaint about it. Mr. Pellissier spoke of pipe lines welded by the thermit process, reference to certain of which was made in his paper, and one of which, for the New York Central Railroad at Albany, is working under 1500 lb. pressure per sq. in. W. H. Noxon spoke of a large textile concern in Massachusetts that had a complete system of welded steam pipes throughout the plant. They not only use steam for power, but in the processes of manufacture. It was required a short time ago that a welder should go from Boston to the factory and weld in two nipples. The superintendent would not allow them to drill and tap the pipe and screw in the nipples. It is understood that there are no leaks whatever in the piping. When a pipe line is properly welded it does away with a vast amount of repairing afterwards.

Henry Cave, in reference to welding castings, held that little work on large castings had been done under the best conditions. He believed that any part which had been cast and cooled could be welded if the original conditions were reproduced; that is, if the casting were heated up very slowly in a muffle, so that its temperature would rise uniformly to a dull red, it could be welded successfully. He believed, however, that it was practically impossible to weld up a shrinking crack that had occurred during the cooling of a casting, because the same cause which made it crack in the first place would make it crack in the weld.

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[1] Simmon's Pipe Bending Works, Newark, N. J.

CONTRIBUTED DISCUSSION

L. P. Alford had prepared a discussion, which was read in his absence by J. D. Mooney, on the autogenous welding of locomotive repair parts. It related to the use of a largely home made oxy-acetylene plant constructed by The Atchison, Topeka and Santa Fé Railway at Topeka, Kans. Some years ago this company awoke to the enormous possibility of oxy-acetylene welding in making repairs to locomotives. After investigating available equipments, it was decided that all were too small for railroad shop needs. A plant with facilities for supplying 200 cu. ft. of oxygen and acetylene an hour was completed about two years ago and has proven so successful that another plant of the same general design has just been placed in operation. The new plant has a capacity of 1000 cu. ft. of oxygen and an equal amount of acetylene an hour. Oxygen is generated by boiling a saturated solution of bleaching powder in a water-tight tank and adding to this at regular intervals a saturated solution of iron sulphate and copper sulphate. The acetylene is manufactured by the usual carbide feed.

In locomotive repairs the use of autogenous welding is being rapidly extended, and many iron and steel castings and forgings are repaired in this manner at an expense much less than the cost of renewal. Worn parts, such as links, eccentric blades, crossheads, pistons, valve rods, truck and trailer hangers, and waist sheets, are repaired with a considerable saving of time and money. Repairs to steel cabs, steel running boards, ashpans, tender cisterns, and air and oil reservoirs can be expedited and made at reduced cost by the oxy-acetylene process. New work of this nature can be made without joints at reduced initial expense and not unlikely reduced maintenance. With a sufficient supply of gas to permit continuous operation at the necessary pressure, main frames can be welded in position, patches applied to broken cylinder castings, cracked bridges in valve chambers repaired and broken spokes welded in driving wheels.

Nor is the application of autogenous welding confined to the locomotive shop; the advent of steel construction in passenger coaches and freight cars offers unlimited opportunities for it in the car shop. The process is especially suited to the welding of the thin sheets of the head lining or siding and the application of bracing at the window framing in the all-steel coach when being built new; this is also true of patch work when these parts are in need of repairs. The liability of leaks would be eliminated on oil tank cars if the sheets were welded together in place of riveted, which would be an important item in the transportation of the lighter oils; welded tank cars could be maintained at less expense and would remain in service for longer periods. Repairs to the bodies of steel freight cars can be handled in many instances to better advantage by the oxy-acetylene blowpipe than by the air hammer; this is also true of many repairs to steel underframes.

In the presentation of the discussion numerous slides were shown of repairs that had been made on locomotive parts and cost figures were given. A few of these examples are here referred to, based upon data supplied to the author by H. W. Jacobs, Assistant Superintendent of Motive Power.

By the building up of the crosshead fit on a piston rod and returning at an expense of $3, the old rod is made serviceable. A new piston rod would cost from $12.50 to $18.

Links become worn either by the eccentric blades or by the blocks, making renewal necessary under the old method; however, by building up the worn places with the welding torch at a cost of $4.02, the necessity of supplying a new link at a cost of $43.40 is removed.

The teeth in quadrants become worn and broken, making it necessary by the old method to insert new teeth by dovetailing at an expense of $1.38 for an insertion of two teeth; with the autogenous process two new teeth can be built up and dressed at a cost of 71 cents. The quadrant is considerably stronger when repaired by welding than when repaired by inserting dovetails.

When the back ends of the main frames become badly worn on the top and inside from the working deck casting, it becomes necessary to remove the rame and fittings and to have the frame reinforced at the blacksmith shop, machined, and put back into place. The autogenous process makes it unnecessary to remove the frame. In one case the repairs amounted to $5.25. If the frame had been removed and repaired in the blacksmith shop the total cost of the repairs would have been $41.13.

A crosshead taken from an engine in the shop for general repairs was found to be cracked in front of and above the keyway; it was unfit for further service as it could not be patched satisfactorily. It was welded at a total cost of $3.12 in place of supplying a new crosshead at a cost of $29.40.

The reverse levers become worn by the quadrant reach rod and latch connections. A lever was built up in the worn places at a total cost of $2.30. To cut out, insert and fit up the central part of the lever would have cost $7.65.

A wrought-iron frame brace became badly worn on one end, due to the action of a spring hanger. To weld on a new end and fit it up, including material cost and labor charges in both blacksmith and machine shops, would have cost $4.42. By building up the worn place by the autogenous method at a cost of $1.69, a saving of $2.73 was effected and the delay to the engine was also reduced considerably.

In making repairs to steel cabs or making changes due to a change of location of the piping, it is often necessary to renew the entire end of the cab in order to secure the necessary strength. In one instance this was avoided by the application of four patches on a steel cab by autogenous welding at a cost of $14.06, as compared with $27.64 for a new end.

Henry Cave[1], in a written communication, took exception to the contention of the author of the first paper that the word "Autogenous" is not a correct term for the use of the oxy-acetylene flame for welding. The weld is made by merely liquifying the parts so that they run together, the liquifaction being produced by applying heat. The application of the heat cannot in itself be considered a part of making the weld, as the weld does not occur until the parts become fluid and run together.

While in a large proportion of the work carried out by this process it is necessary to add metal from a rod, this is merely incidental. The weld as made automatically in a machine, on thin sheet metal, consists in butting the edges together and applying heat, when the parts run together and are actually autogenously welded.

Criticism was also made of the designation made by the author of this paper of the two principal types of torches as "Injector" and "Pressure," commonly referred to as "Low Pressure" and "High Pressure" torches. It was contended in the discussion that all nomenclature should be based on the principal feature of the article being spoken of, and the principal feature in torches relates to the way in which the mixture is produced.

In the "Low-Pressure" or "Injector" type torch the mixture is made by injecting a jet of oxygen through a chamber of acetylene with the result that a stream of gas passes out of the tip having its core mainly oxygen and an annulus mainly acetylene, the mixture not being homogeneous and the proportion of the two gases varying between 1.00 of acetylene to 1.40 oxygen and 1.00 acetylene to 1.80 oxygen. This being distinctly an injector type torch, the fact that it uses acetylene from a low-pressure generator, or acetylene at a low pressure, has nothing to do with the torch itself, and the use of acetylene under pressure in this torch does not, in any way, affect the type.

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[1] President, Autogenous Welding Equipment Company, Springfield, Mass.

In a "Pressure" torch, or what is more correctly termed a "Pressure Positive Mixture" torch, the oxygen flows through a passage in the center under pressure. The acetylene passage is at an angle to the oxygen passage and is also under pressure. The two striking together at a considerable angle and with considerable force, thus giving a very intimate molecular contact of the gases, with the result that a homogeneous stream of gas flows from the tip and the mixture produced contains 1.28 of oxygen to 1.00 of acetylene, the proportion of the gases being positively regulated by the size of the ports through which the gas enters the mixture chamber and not in any way controlled by injector action. The mixture therefore is made in an entirely different manner from the low pressure or injector type torch, and the term "Pressure" is perfectly correct in this case, as is also "Positive Mixture."

This should be emphasized, as those who have not studied the proposition do not realize that an injector type or low-pressure torch cannot be made into a pressure torch by merely increasing the pressure of the acetylene supplied.

One of the obvious uses for this process is the repair and even the manufacture of steam boilers. The regulations governing this class of work, however, restrict its use to some extent. This is entirely due to ignorance of the process and its possibilities, and also to the fact that a great deal of poor work has been produced abroad.

The writer quoted from letters showing that inferior work done abroad, due to the installation of cheap equipments, had been detrimental to the industry and had tended to raise suspicion as to the quality of work which could be accomplished. He advocated the licensing of operators and plants, believing this to be the only way to insure good work being carried out on boilers. By this means there might be a revision of the restrictions imposed. At the present time there are a number of cheap equipments which have been placed on the market in this country, in connection with which it would not be possible to give proper instructions to operators.

It was thought that the author of the paper under discussion might wish to qualify the use of the word "approved" in connection with the apparatus at the Santa Fé shops at Topeka, in which he states that a water to carbide generator is used, in view of the following extract from a paper by the president of the British Acetylene Association:

> "I am of the opinion that the dipping or displacement type of generator should not be employed for welding plants; polymerization nearly always occurs in this type and the delivery pressure is an uncertain factor. No one compartment of a generator of this type should decompose more than 4 lb. of carbide per hour, which would yield about 18 cu. ft. of gas. If a generator of this type is allowed to decompose carbide at a faster rate, trouble is bound to come. Overheating will take place in the generator and polymerization will ensue. Some of the hydro-carbons so formed when mixed with acetylene are highly injurious to molten metal, and eradication of some of these hydro-carbons is practically impossible. Not only are they injurious to the metal, but their combustion necessitates more oxygen than is necessary for pure acetylene."

J. F. Springer. The little working flame of an oxy-acetylene blowpipe is very short in spite of the fact that the gases are under pressure. We must conclude, then, that the splitting up of the acetylene into carbon and hydrogen and the subsequent union of equal volumes of carbon and oxygen to form the monoxide must take place in an incredibly short interval of time. Indeed, I do not think it is too much to say that the remarkably high temperature of the white flame is due largely to a lightning-like pairing off of carbon and oxygen molecules.

Theoretically, one volume of oxygen is needed to effect the required results with one volume of acetylene. But with all the oxy-acetylene torches—without exception, I believe—an excess of oxygen is always furnished. In some cases this excess is 50 to 80 per cent. In the Davis-Bournonville torch—and perhaps some others—this percentage is reduced to 28; so that the standard mixture of oxygen and acetylene, which flows from the tips of these torches, consists of 1.28 parts of oxygen to one part acetylene. Now why is it that these various amounts of excess must be furnished? I believe it is due to nothing else than to the varying degrees of perfection with which the *mixing* is accomplished. In the typical Davis-Bournonville torch the oxygen comes into the straight-away mixing chamber along the axis. Just subsequent to its entrance, four acetylene jets strike the oxygen stream perpendicularly from the sides. A proper term for this type of tip would be the ejector tip—the oxygen drives the acetylene. It is not difficult to see that we have here very perfect conditions. That they are truly so is shown, I think, by the fact that so small an excess of oxygen is required.

The Davis-Bournonville Company is sanguine of putting on the market soon a style of tip whereby the oxygen excess will be cut in two. That is to say, this company expects to use a mixture containing only 13 per cent more oxygen than is theoretically requisite to burn the carbon to the monoxide.

Is this important? Consider a moment. Here is a highly heated steel surface against which the outer end of the little white flame is playing. It is reasonable to assume that hydrogen, carbon monoxide and the excess oxygen are impinging on this surface. The first two are, no doubt, harmless. But how about the uncombined oxygen? Is it harmless? We shall want good reasons to enable us to conclude that a stream of free oxygen playing on red or white hot steel is harmless. It may be urged that with the reduction in temperature, the excess oxygen will be absorbed by the carbon monoxide and the hydrogen. No doubt there is a large amount of such absorption. The generally excellent character of oxy-acetylene welds testifies to this. The ideal thing, however, is to weld the steel without any oxidation. There are three claimants for the oxygen—the carbon monoxide, the hydrogen and the highly heated steel. When the excess oxygen is present in considerable quantity, who can doubt but that the steel secures some oxygen to its own detriment? With the present Davis-Bournonville tip, the excess oxygen is comparatively small; with the new form of tip we have reason to hope it will become well nigh harmless.

HERRINGBONE GEARS

By Percy C. Day

ABSTRACT OF PAPER

This paper relates especially to a type of herringbone gears, known as Wuest gears, after the name of the inventor. The distinctive feature of these gears is that the teeth on one side of the center line of the face are stepped half the pitch ahead of those on the other side, so that they do not meet at a common apex at the center line, as in the ordinary herringbone type. This arrangement makes it possible to hub the teeth by the aid of special machinery, and to secure great precision. The paper further discusses the principles, action, and methods of construction of herringbone gears, contrasting them with spur gears, and gives data upon the proportions and strength of Wuest gears. The paper concludes with examples of the application of these gears to various machines, including cases where high speed, high ratios of reductions and the absence of backlash are to be attained.

HERRINGBONE GEARS

WITH SPECIAL REFERENCE TO THE WUEST SYSTEM

By Percy C. Day,[1] Milwaukee, Wis.

Non-Member

That the helical principle in toothed gearing is ideal from a theoretical point of view is well known. From a practical standpoint herringbone gears have been less satisfactory than straight-cut spur gears because, until recently, no method was devised for producing them with the requisite speed and accuracy. Within the last six years a method has been found and developed, in England, to a high degree of perfection. Herringbone gears made by this method are called Wuest gears, after the name of the inventor, and can be produced with even greater accuracy than cut gears of the spur type (Figs. 1 and 2).

2 The distinction between these gears and those of the ordinary herringbone type is that the teeth of the former, instead of joining at a common apex at the center of the face, are stepped half the pitch apart and do not meet at all. This arrangement of the teeth does not affect the action of the gears, but it facilitates their commercial production and admits the use of precision methods in their manufacture.

3 The utilization of power constantly calls for means to transmit rotary motion from one axis to another and to transform the speed of rotation. While there are many ways in which such transmissions and transformations may be produced, the merits of all of them must be judged from the following standards: (*a*) reliability and freedom from wear and tear; (*b*) economy of outlay; (*c*) mechanical efficiency; (*d*) compactness; (*e*) evenness of transmission, absence of shock, jar or vibration; (*f*) absence of noise. The order of merit may change with different applications, but the same standards obtain for all

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[1] Engineer with The Falk Co.

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transmissions. The various methods employed are so well known that they need no discussion here. Let it suffice to say that the spur gear, which satisfies only the first four conditions, is used to such an extent that all other appliances are relatively unimportant.

ACTION OF SPUR GEARING

4 The aim of all designers of gearing is to transmit rotary motion from one axis to another in a perfectly even manner without variation of angular velocity. Let us consider the action of a straight spur pinion driving a gear. There are three distinct phases of engagement:

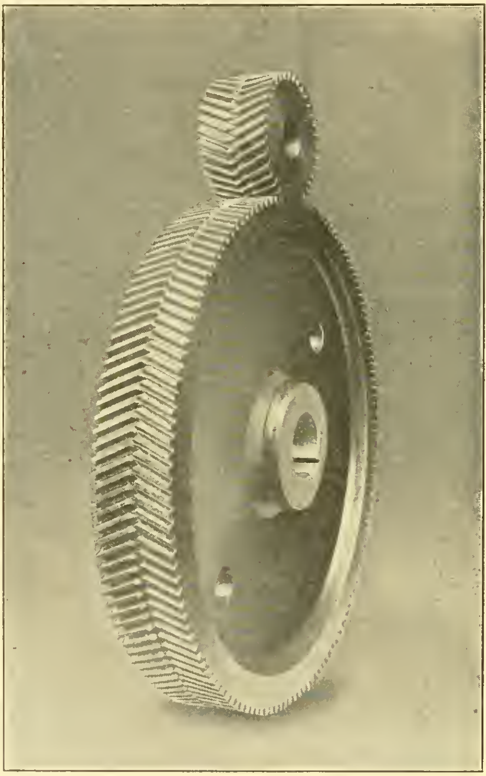


Fig 1 Typical Herringbone Gear and Pinion

a First phase: The root of the pinion tooth engages the point of the gear tooth.

b Second phase: The teeth are engaged near the pitch line.

c Third phase: The point of the pinion tooth engages the root of the gear tooth.

5 Let us assume that the teeth are accurately cut to involute form, so that if the pinion moves with even angular velocity it will produce corresponding evenness of motion in the gear. Also that the pinion has sufficient teeth to allow the engagement of successive teeth to overlap.

6 At the beginning of the first phase, while the load is carried near the point of the gear tooth, that tooth is subjected to a maximum bending stress along its whole length. During the first phase, the portion of the pinion tooth near the root is sensibly sliding over the outer portion of the gear tooth; that is to say, two metallic surfaces of small area are sliding under heavy compression.

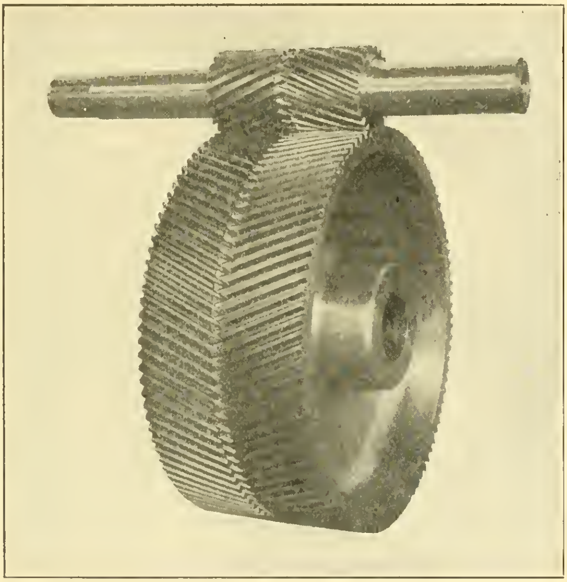


Fig. 2 Gear and Pinion for 200-h.p. Turbine, to Run at 5000 Ft. per Min.

7 The action during the second phase more nearly approaches ideal conditions. The teeth are engaged near their respective pitch lines and very little sliding takes place.

8 During the third and final phase, the pinion tooth is subjected to a maximum bending stress, while the tooth surfaces again slide

over each other, this time with the outer portion of the pinion tooth engaging the gear tooth near its root.

9 The point to be noted is that while those portions of the mating teeth which are near the pitch lines transmit the load with rolling contact, those which are more remote have to transmit the same load with sliding contact. The inevitable result is that the points and roots of all the teeth tend to wear away more rapidly than the portions near the pitch lines, so that the involute tooth curves, necessary to the preservation of even angular velocity, lose their form and the motion becomes uneven.

10 It may be suggested that the sliding action can be got rid of by shortening the teeth so that they engage only the phase of rolling contact. This has been tried with a certain measure of success in the stub-toothed gear, but it cannot be carried far enough without curtailing the arc of contact so that continuity of engagement is lost, thereby introducing more serious trouble than that which it is desired to avoid.

11 Distortions of gear teeth from involute form, whether due to inaccurate cutting or subsequent wear, give rise to all kinds of trouble.. The average angular velocity may be uniform, and yet the passage of each pinion tooth through its brief engagement with the mating gear may be accompanied by successive retardation and acceleration which, though small in itself, takes place in such a short interval of time that it may cause interacting stresses many times greater than the average working load on the teeth. These internal stresses are very difficult to deal with, because they are indeterminate. They cause noise, vibration, crystallization and fracture.

ACTION OF HERRINGBONE GEARS

12 Herringbone gears completely overcome all these difficulties, but only when they are accurately cut.

13 The writer will first assume the accuracy and describe the action, afterwards he will endeavor to show how the system under discussion has special features which insure the production of accurate herringbone gears on a commercial scale.

14 If we take two exactly similar pinions with straight teeth and place them side by side on one shaft, with the teeth of one pinion set opposite the spaces of the other, then we have what is known as a stepped-tooth pinion. If this pinion is meshed with a composite gear made up in a similar manner, the action is modified so that there are always two phases of engagement taking place simultaneously.

Such gears are commonly used for rolling mill work, because they stand up to heavy shocks better than the plain type.

15 Still better action can be secured by assembling a number of narrow pinions with the last of the series one pitch in advance of the first and the others advanced by equal angular increments. As a practical proposition, however, gears made on these lines would be costly and difficult to produce.

16 The helical gear is the logical outcome of the stepped gear carried to its limit, and built up from infinitely thin laminations. Since the steps have merged into a helix, there must be a normal component of the tangential pressure on the teeth, producing end thrust on the shafts. To obviate end thrust, the helical teeth are made right-hand on one side of the face and left-hand on the other. Such gears, with double helical teeth, are known as herringbone gears.

17 The fundamental principle of the action of herringbone teeth lies in the circumstance that *all phases of engagement take place simultaneously.* This holds good for every position of pinion and gear, provided only that the relationship between pitch, face width, and spiral angle is such as will insure a complete overlap of engagement.

18 Since all phases of engagement occur together, it follows that the load is partly carried by tooth surfaces in sliding contact and partly by surfaces in rolling contact. The result is curious and interesting.

19 Those portions of the teeth farthest from the pitch line, which engage with sliding action, tend to wear away more rapidly than the portions nearest the pitch line. But the pitch line portion is always carrying part of the load, and the effect of wear on the ends of the teeth merely tends to throw more load on the center portions; in other words *there is a tendency to concentrate the load near the pitch lines.* The ends of the teeth, instead of wearing away to an ever-increasing extent from their original involute form, are relieved of some of the load from the moment that wear commences to take place. As soon as the load on these ends has been partially relieved and transferred to the middle portion, the wear becomes equalized all over the teeth and they do not tend to distort further from their original shape.

20 It is quite clear that an unmeasurable amount of wear on the tooth ends will be sufficient to relieve them of all the load, so that the distortion from original form will be practically nothing. The minute extra wear that does take place at the ends is only the amount necessary to transfer such proportion of the load near the

pitch lines that the wear is equalized all over the surface of the teeth, those portions in sliding contact carrying less than those in rolling contact.

21 Thus the teeth keep their involute form, and motion is transmitted from pinion to gear in a perfectly even manner, without jar, shock, or vibration. Although herringbone teeth may not be intrinsically stronger than straight teeth, the elimination of all shock and indeterminate internal stresses renders them capable of dealing with far heavier transmitted loads. The concentration of the major portion of the load on the parts of the teeth in rolling contact eliminates friction to a marked extent.

22 Since all phases of engagement occur simultaneously, the transference of the load from one pinion tooth to the next takes place gradually instead of suddenly. This is the second principle of herringbone gearing, and may be termed *continuity of action.* In straight gears the continuity of action is a function of the number of teeth in the pinion. Straight pinions with less than twelve teeth are seldom made, and more than that number must be used if the drive is to be even moderately satisfactory.

23 In herringbone gears continuity depends on the relationship between the face width and the number of teeth in the pinion. Pinions with as few as five teeth have been used with success by merely increasing the face width to suit such extreme conditions. This feature, which is peculiar to herringbone gears, has made practical the adoption of extremely high ratios of reduction hitherto considered impossible.

24 The third principle of herringbone gearing is that *the bending stress on the teeth does not fluctuate from maximum to minimum as* in straight gears, *but remains always near the mean value.* This feature is of special importance in rolling-mill driving and work of a similar nature.

25 To summarize the foregoing arguments: The action of herringbone gears is continuous and smooth; there is no shock of transference from tooth to tooth; the teeth do not wear out of shape; the bending action of the load on the teeth is less than with straight gearing and does not fluctuate to anything like the same extent; the gears work silently and without vibration; the phenomenon commonly termed back-lash is absent; friction and mechanical losses are reduced to a minimum; herringbone gears can be used for higher ratios and greater velocities than any other kind.

26 These advantages are limited to gears which can be produced

with a degree of accuracy which will insure the practical realization of the principles involved.

THE PRODUCTION OF HERRINGBONE GEARS

27 Herringbone gears may be produced in a variety of ways which differ from each other as widely as the character of the product. Until a few years ago all gears of this type were molded. The limitations of molded gearing are analogous to those which would be experienced if a journal were set to run in a molded bearing. Just as the bearing would touch the shaft only in spots, so molded gears utterly fail to give the intimate contact all along the teeth which is necessary to secure the realization of true helical gear action. It is obvious that if the teeth touch only in a few high places, they will be subjected to all the evils of shock, stress, and inequality of motion which it is desired to avoid. If the gears are particularly well molded, some mitigation may be expected when they become well worn, but initial wear is accompanied by a departure from correct tooth shape.

28 For slow speeds a well-molded helical gear is no better than a straight gear with cut teeth, and for high speeds it is not as good. The natural smoothness of helical action does no more than compensate for the inaccuracies of tooth form and spacing. The modern herringbone gear must have cut teeth if its advantages are to become real.

29 Cut herringbone gears may be broadly divided into two classes, two-piece and one-piece gears. The difficulty in the way of cutting double helical teeth in a single blank gave rise to the two-piece variety. The same methods of cutting may be used for both kinds.

30 The disadvantages of the two-piece type are fairly obvious. There is the expense of two complete gears, the difficulty of assembling the gears so they are in accurate register with each other, and the necessity for very complete fixing if they are to perform hard service without getting out of register.

31 High ratios, perhaps the strongest feature of the one-piece type, are not within the scope of the built-up gear, because the pinions must be assembled on a separate shaft and the pitch line must be far enough from the surface of the shaft to allow room for the necessary bolts or rivets used in fastening the two portions together.

32 The one-piece pinion, however, may be cut solid with its shaft, so that its pitch diameter need be but very little larger than the latter.

33 The known methods of cutting helical gears may be divided

into four classes: (*a*) milling by formed disc cutters; (*b*) milling by end mills; (*c*) generating by shaping or planing methods; (*d*) generating by hobs.

34 Milling by formed disc cutters is unsatisfactory because, in addition to the usual errors of step-by-step division, there is the difficulty of making the cutters to the *normal* tooth shape with sufficient accuracy to insure correct circumferential shape for the gears cut. This difficulty is increased by reason of the fact that a disc cutter cannot cut its own shape in a spiral groove. Let it be noted that the cutters must be formed empirically, that their number must be very large to meet the requirements of a general gear business, and that the accuracy of each gear turned out depends on the combined efforts of the toolmaker and draftsman who produced the cutter. Worst of all, two different cutters must be used for a gear and pinion. This method will produce indifferent herringbone gears which may be built up with teeth in register or made in one piece with staggered teeth.

35 The use of end-mills is open to all the objections given with regard to disc cutters, with the single exception that the cutter does leave a fair approximation to its own shape in the groove which it cuts. The end-mill has a host of disadvantages peculiar to itself which render it even less efficient than the disc cutter for general work. In the first place, it is a small tool with very little wearing surface and no capacity for dissipating the heat generated at its cutting edges. The great variation in diameter between point and base renders it difficult to arrive at a cutting speed which will satisfy the conditions at both ends of the cut. When used for any but the largest pitches, outside the range of general gear practice, the mills quickly become clogged with cuttings, overheat and burn. A burnt end-mill, clogged with cuttings, produces a wider groove than a good mill. This is a fruitful source of spoiled work. To complete one fair sized gear by the end-mill process requires quite a number of cutters. This not only makes the expense heavy, but must necessarily result in an inaccurate gear.

36 Every cutter used must be formed to gage and hardened. After being hardened, it will run out of true a little in most cases, thereby cutting a shape different from that for which it was designed. In end-mill gears it is not merely a case of getting accurate conjugate tooth shapes in gear and pinion made with different cutters, but the teeth in a single gear may have a dozen different shapes. The process is so slow that it cannot compete with other methods, quite apart from the doubtful quality of the gears produced.

37 End-milled herringbone gears are usually made in one piece with the teeth joined at the center. Since the cutter is shaped to the *normal* pitch, it follows that, in changing over from right to left-hand helix, it leaves a thick wedge in the center of the face that must be removed by a subsequent operation. The teeth of end-milled herringbone gears do not bear over the center portion.

38 Generating processes by the shaping and planing types, while successful for straight-cut gears of relatively small size, are not used to any extent for large diameters or heavy pitches. The reason for this may be found in the nature of such processes. The gear blank is required to make a quick angular movement after each stroke of the cutting tool and to come to rest again before the next stroke. Such methods are difficult to apply to large gears on account of the inertia of the gear blank and its support and the consequent difficulties of controlling the short intermittent movements. These difficulties are much increased when such methods are applied to cutting helical teeth because the blank must make definite and rapid angular movements during each stroke in addition to the motion between strokes. No machine has been devised which will satisfactorily deal with the problem on these lines.

39 The hobbing process as supplied to straight-cut gears has proved so successful as to arouse a storm of adverse criticism from those who are interested in other methods of gear production. It is not difficult to understand why this process has sprung into prominence in a comparatively short time. It is essentially a rational pro - ess. The shape of the teeth is generated from spiral hobs, the threads of which are cut to a plain rack section. There is nothing empirical about a hob; it is a straightforward thread cutting, gashing and relieving proposition. One hob will cut any gear or pinion of one pitch. This feature alone eliminates a host of errors which are characteristic of gears produced by milling methods. The hob revolves continuously while cutting, as does the gear blank. The feed is also continuous. There are no cutting and return strokes, no intermittent starting and stopping of gear blanks, as in other generating processes. These features do not necessarily insure the production of accurate gears, but they offer greater facilities to the designer for the achievement of the desired result. The hob is a substantial tool with plenty of wearing and cooling surface, it can be made to stand up to very fast production and to last for a long time. The continuous nature of all motions used in hobbing a gear blank enables this process to be used for the production of the heaviest

gears, there are no limitations such as are encountered in other processes. The limit to the size of a hobbing machine is set by the dimensions of the largest gears which are required in sufficient quantities to pay for the investment. There are no technical limits whatever.

40 Nevertheless, there are some slight defects in the hobbing process as applied to the production of straight-cut spur gears. A hob is a worm thread, and as such must have a spiral angle depending on the relationship between the pitch of the thread and the diameter of the hob. A straight-cut gear has no spiral angle, hence the spiral hob must be inclined, more or less, to bring the cutters in line with the tooth spaces to be cut. In order to cut correct teeth, the axis of the hob should be perpendicular to the axis of the gear blank. In such case the hob will generate involute teeth if its threads are cut to the same axial section as the straight-sided parent rack for the required pitch. Since the hob must be inclined to cut a spur gear, the teeth are not generated from the axial or rack section, but from a diagonal section. The axial pitch of a hob for cutting spur gears is not the same as the pitch of the gears, which it cuts. The normal pitch of the hob threads must be the same as the gear pitch.

41 Hobs for cutting straight spur gears are usually made of large diameter to reduce the spiral angle and consequent errors of tooth form to a negligible minimum. As a natural consequence, such hobs have only one thread, while their large diameter requires a slow speed of rotation to keep the cutting speed within proper limits. The effect of this is that the blank revolves very slowly, and a coarse feed must be used to keep up the output.

42 It is one of the peculiarities of each hob action that only one tooth of the hob puts the finishing touch to the bottom of a tooth space once in each revolution of the gear blank. If the feed is coarse, there will be noticeable feed marks and roughness in the gear teeth produced. A coarse feed used with a hob of large radius throws severe stresses on the hob arbor and its supports.

43 The necessity of a swivel motion on the hob slide, to enable straight spurs to be cut with hobs of varying spiral angle, compels the use of a hob drive which passes through the pivot. It is almost impossible to design such an arrangement without undesirable restriction in the dimensions of driving gears and shafts combined with excessive overhang of the hob arbor in relation to its supporting slide.

44 The general want of rigidity about most hobbing machines used for the production of spur gears, is traceable to the above causes.

Rational critics of the hobbing process have based their objections on these features.

45 The hobbing process properly applied to the production of herringbone gears has none of the disadvantages, incidental to its application to spur gear cutting, which have been shown to lie in the necessity of inclining the hob axis. Since a helical gear and a hob must both have a spiral angle, it is only necessary to make the thread angle of the hob the complement to the corresponding angle of the gear teeth to secure the advantages of perpendicular fixed axes. These are of great practical value. Since the hob axis is always perpendicular to the axis of the gear blank, it follows that the teeth are generated from the axial and true rack section of the hob, while the linear pitch of the hob is the same as the circular pitch of the gear which it cuts. The hob axis is fixed and the hob can be supported on a rigid slide with the minimum of overhang. There is no restriction to the size and strength of the gears and shafts used to drive the hob.

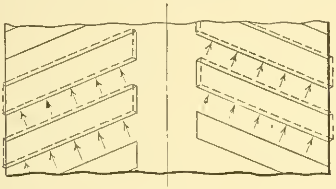


FIG. 3

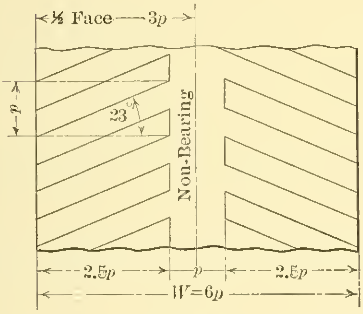


FIG. 5

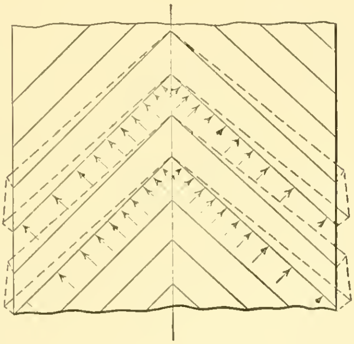


FIG. 4

FIGS. 3 TO 5 DIAGRAMS SHOWING TOOTH PRESSURES AND ANGLE NECESSARY FOR CONTINUITY OF ACTION

WUEST HERRINGBONE GEARS

46 It was explained in Par. 2 that the teeth of the Wuest gears are so designed that those on the right and left-hand sides of the

gear are stepped half a space apart and do not meet at a common apex at the center of the face, as in the usual type of herringbone gear. It has often been argued that the ordinary herringbone tooth is stronger than the Wuest tooth, because the latter lacks the support given by the junction of the teeth at the center. This argument would be sound if gear teeth were ever stressed to anywhere near their breaking point. But it has been found in practice that considerations of wear so far outweigh those of mere breaking strength that a gear which is designed to give reasonable service will carry anywhere from ten to twenty times the working load without fracture. A point of vastly greater importance is that the stepped form will wear more evenly under extreme loads than the ordinary type. The reason for this is shown in Figs. 3 and 4. The resultant tooth pressure is always normal to the teeth and tends to bend them apart. The stepped form offers a uniform resistance along its whole length, carrying the load from end to end (Fig. 3). The teeth of ordinary herringbone gears tend to separate more at the sides than near the supported center, causing the load to be concentrated toward the center (Fig. 4).

47 Any system of gearing, if it is to be generally applied, must be interchangeable. The variable features of involute spur gear teeth are limited to the pressure angle, addendum and dedendum. In a herringbone-gear system, we must have, besides, uniformity of spiral angle and relative position of the right and left-hand teeth.

48 The standards which have been adopted for Wuest gears are the result of experience gained in Europe during the last six years. The spiral angle of the teeth is about 23 deg. with the axis. The choice of this angle is controlled by a number of considerations, the most important from the user's standpoint being that the angle must be sufficient to allow the engagement of successive pinion teeth to overlap within a reasonable face width. Once this condition is satisfied, there is no advantage in an increase of spiral angle, while there are disadvantages in the use of steep angles. It was necessary, before choosing a definite spiral angle, to determine what constitutes a reasonable face width for this class of gearing.

49 Since the nature of the action eliminates shock, it follows that the pitch required for given conditions will be much finer than would be chosen for spur gears. On the other hand, the face width will not be less, because there is as much necessity for wearing surface with one kind of tooth as with the other. Spur gears are usually made with face width equal to three or four times the pitch. Herringbone gears may conveniently have a face width equal to six times the pitch

not because the width of this type need actually be greater, but by reason of the pitch being proportionately less.

50 Starting with a width equal to six times the pitch, and allowing once the pitch as the non-bearing portion in the center, there remains two and one-half times the pitch available for the teeth on each side. To insure continuity of engagement under all ordinary conditions, each tooth is inclined so as to cover an advance of once the pitch within its length. The angle of 23 deg. satisfies this requirement (see Fig. 5). There are a few cases where an angle less than 23 deg. would be sufficient, a steeper angle is only needed if the available face width has to be unduly restricted. Neither of these extreme conditions should influence the choice of angle for an interchangeable system best adapted for general use.

51 There are other good reasons why a moderate spiral angle is to be preferred. In all spiral gears the pressure acts in a direction normal to the teeth and is the resultant of the tangential (driving) and axial pressures. The normal pressure becomes greater in proportion to the useful driving pressure as the spiral angle is increased, while the available normal tooth section becomes less (Fig. 6). When the spiral angle is sensibly steeper than the angle of repose for the materials in contact, there is a tendency for the teeth to bind with a wedge action. Herringbone gears with abnormally steep spiral angles show loss of efficiency and increased wear from this cause.

52 The pressure angle which has been adopted for standard gears is 20 deg. The teeth are shorter than the usual standards, with addendum 0.8 and dedendum 1.0. These standards of tooth height and pressure angle have been adopted after systematic trials and experience extending over several years of regular manufacture. The high ratios used with these gears call for an average pinion diameter which is less than is used with straight spur-gears for similar duty. The teeth are generated by hobs, and the short addendum combined with wide angle gives satisfactory tooth shapes, without undercutting of teeth, for small pinions. Pinions with very few teeth are cut on the well-known system of enlarged addendum which is used for small wormwheels and bevel pinions. The teeth are cut to diametral pitch standards, measured circumferentially as with ordinary spur gearing.

53 The dimensions proposed for an interchangeable system for these gears are as follows:

Tooth shape...Involute
Pressure angle...20 deg.
Spiral angle...23 deg.

$$\text{Pitch diameter (20 teeth and over)} = \frac{\text{Number of teeth}}{\text{D.P.}}$$

$$\text{Blank diameter (20 teeth and over)} = \frac{\text{Number of teeth} + 1.6}{\text{D.P.}}$$

$$\text{Pitch diameter (under 20 teeth)} = \frac{0.95 \times \text{Number of teeth} + 1}{\text{D.P.}}$$

$$\text{Blank diameter (under 20 teeth)} = \frac{0.95 \times \text{Number of teeth} + 2.6}{\text{D.P.}}$$

Addendum...$\frac{0.8}{\text{D.P.}}$

Dedendum...$\frac{1.0}{\text{D.P.}}$

Full depth...$\frac{1.8}{\text{D.P.}}$

Working depth...$\frac{1.6}{\text{D.P.}}$

Standard face width for gears with pinions of not less than 25 teeth.............................6 times circular pitch
Face widths for high ratio gears with small pinions..........................6 to 12 times circular pitch

54 When a pinion of less than 20 teeth is used with a standard gear, the center distance must be slightly increased to suit the enlargement of the pinion. If it is desired to keep the center distance to the standard dimensions, the gear diameter may be reduced by the amount of the enlargement given to the pinion. For example: If a pinion of 10 teeth, 5 D.P. is to mesh with a gear of 90 teeth at 10 in. centers,

$$\text{Pitch diameter of pinion} = \frac{0.95 \times 10 + 1}{5} = 2.1 \text{ in.}$$

$$\text{Enlargement over standard pinion} = 0.1 \text{ in.}$$

$$\text{Pitch diameter of standard gear} = \frac{90}{5} = 18.0 \text{ in.}$$

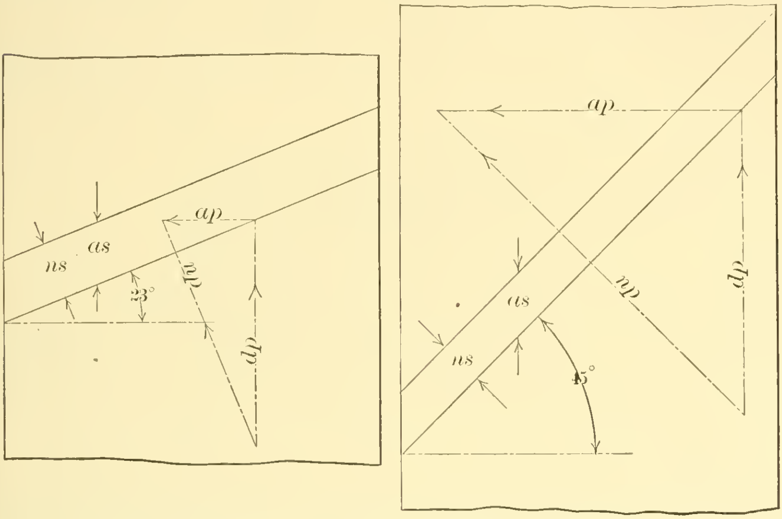
$$\text{Reduced pitch diameter of gear} = 18.0 - 0.1 = 17.9 \text{ in.}$$

$$\text{Center distance} = \frac{17.9 + 2.1}{2} = 10 \text{ in.}$$

Strictly speaking, there can be no enlargement or reduction of the pitch diameter in a pinion or gear of given pitch and number of teeth.

It is convenient to assume this enlargement and reduction, while using teeth with long and short addenda but standard depth.

55 In these gears the teeth need not have the same breaking strength as with spur gears because they have not to combat the heavy and indeterminate stresses which arise from inequalities of angular velocity. On the other hand it is necessary to provide against rapid wear. By using a finer pitch, each tooth has less individual wearing surface, but this is more than compensated for by the larger number of teeth in simultaneous contact than with gears of equal diameters but coarser pitch.



		23 Deg.	45 Deg.
as	Axial Section		
ns	Normal Section	$ns=0.9205\ as$	$0.707\ as$
dp	Driving Pressure	———	———
ap	End of Wedge Pressure	$ap=0.424\ dp$	$1.0\ dp$
np	Normal Pressure	$np=1.09\ dp$	$1.414\ dp$
	Relative	$\frac{np}{ns}=1.19$	2.0

Fig. 6

Fig. 6 Relation of Driving Pressure to Angle of Teeth

56 In high ratio gears, using pinions of exceptionally small diameter, the pitch is finer than for ordinary ratios, but the face width is extended to give the proper wearing surface.

57 The important factor in determining the proportions of the teeth is the relationship between pitch line velocity and the per-

missible specific tooth pressure; in other words, the total tooth pressure divided by the area of all the available simultaneous contact along the teeth. Theoretically, this contact has no area since it should consist of lines without breadth. Actually, an area exists, due to the elastic compression of the teeth in contact, in a similar way in which an area of contact exists between a car wheel and a rail. The area of contact is indeterminate, but the specific tooth pressure is proportional to the driving stress on the teeth.

58 In order to obtain a simple rule for finding the proper dimensions, the results of experience in the matter of safe working loads under given conditions have been reduced to a relationship between pitch line velocity and the shearing stress on the pitch line thickness of an imaginary straight tooth, assuming only one tooth in engagement at a time. The shearing stress is a measure of the specific tooth pressure, and the relationship referred to affords a convenient means of arriving at reliable dimensions. The curves, Fig. 7, give values of shearing stress K in pounds per square inch on pitch line section of an imaginary single tooth for corresponding pitch line velocities V in feet per minute. The values are entirely empirical, but they are based on the results of extended experience, and lead to dimensions which are safe and reliable. Different curves are given for different materials, and it is necessary to use that curve which corresponds to the lowest grade material of the combination. The dimensions of gears can be derived from the curves in the following manner:

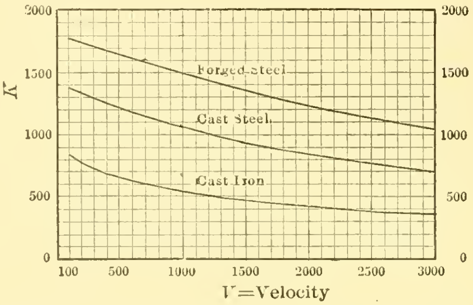


Fig. 7 Shearing Stress in Relation to Pitch-Line Velocity

h.p. = brake horsepower transmitted
N = revolutions per min.
D = pitch circle diameter, in.
p = circular pitch in inches (use nearest diametral pitch)

W = total width of face, in.
V = pitch line velocity, ft. per min.
P = total tooth pressure at pitch line, lb.
K = stress factor (from curve)

$$V = \frac{\pi DN}{12} \quad \text{[1]}$$

$$P = \frac{\text{h.p.} \times 33.000}{V} \quad \text{[2]}$$

$$P = \frac{pWK}{2} \quad \text{[3]}$$

$$P = 3p^2K \left(\begin{array}{l}\text{in normal gears of moderate ratio, and face}\\ \text{width equivalent to six times the circular pitch}\end{array}\right) \quad \text{[4]}$$

$$p = \sqrt{\frac{P}{3K}} \quad \text{[5]}$$

For high ratio gears take $W = Rp$ (R = ratio to 1) up to maximum of $W = 10p$.

$$p = \sqrt{\frac{2.5P}{RK}} \quad \text{[6]}$$

59 Usually the values of h.p. and N are known. In many cases the diameters or center distances are fixed, and there is no choice of dimensions. When the diameters are not fixed there are many solutions to the same problem and it becomes largely a matter of experience which to select in order to obtain the most economical and satisfactory gears.

60 In normal gears it is safe to aim at pitch line velocities between 1000 and 2000 ft. per min. with 1500 ft. as a fair average. If the pinion is to be fixed to a motor shaft without external support, the diameter must be greater than when it can be supported on both sides. Cast-iron is preferable to cast-steel for gears of large diameters and moderate power, but the latter will be found more economical for high tooth pressures. Pinions are usually made from steel forgings of 0.40 to 0.50 per cent carbon. Soft pinions should never be used for herringbone gears. Besides being bad engineering practice they are unnecessary, because steel pinions run without noise and last much longer.

61 The following is a typical instance of the range of choice in dimensions: A pump which requires 150 h.p. at 50 r.p.m. is to be driven from a motor at 500 r.p.m. with shaft end $4\frac{1}{2}$ in. in diameter.

If the shaft is unsupported, it is not desirable to use a pinion of less than 10 in. If the shaft is extended to a third bearing a 7½-in. pinion can be used. If the pinion is cut solid on its shaft and coupled to the motor, its diameter can be reduced to 5 in. The three arrangements work out as follows:

	Material for Gear	*V*	*P*	*K*	Diametral Pitch	Face Width
A 10 in. and 100 in.	Cast-iron	1300	3800	500	2	9½
B 7½in. and 75 in.	Cast-iron	975	5100	530	2	12
C 7½in. and 75 in.	Cast-steel	975	5100	1060	2½	7½
D 5 in. and 50 in.	Cast-steel	650	7600	1150	2½	12½

Any of the above gears will do the work satisfactorily. *C* is the most economical, but *B* or *D* would make the least noise. If a gear case is to be provided then *D* will give the most economical combination.

62 The foregoing data can be used for finding the required dimensions of herringbone gears for all general applications. In most cases it is sufficient to calculate the tooth pressure from the average working load. When the maximum load is very far in excess of the average, it is usual to take a mean value between the two. Gears for electric mine hoists and single throw pumps fall within this category. Machine tools, when driven from variable-speed motors, are required to perform maximum duty at minimum speed only for short periods at long intervals. It is sufficient when getting out gears for a drive of this kind to reckon with the rated output of the motor at the mean between its maximum and minimum speed.

63 There are two special cases where the ordinary methods of calculation should not be used. Rolling-mill gears are subjected to stresses which are so far in excess of the average working load that it is necessary to consider carefully the strength of the teeth in regard to possible overloads. Extra high velocity gears, as such are used for steam turbines, require additional wearing surface and are characterized by extreme width of face combined with abnormally fine pitch. These are two extremes in gearing and their design is best left to those who have made a special study of them.

64 Before describing some special applications of these gears to the needs of various industries and machines, it may be of service to summarize the salient features of the gears and the changes of viewpoint which these features have engendered.

65 The smooth and continuous action is virtually independent of the diameter or number of teeth in the pinion. Extremely high ratios

of reduction can be used without fear of uneven driving or undue wear and without need for unwieldy gear diameters which would be disproportionate to the general design. High ratio gears of this type transmit power with practically no more loss than low ratio gears. They are far more efficient than belts, ropes, worm-gears or compound trains of spur gearing, while their adoption results in a wholesale reduction of countershafts and bearings which reduces the power consumption and running costs to a remarkable degree.

66 There are many instances where spur gears cannot be used because the vibration which they set up has a detrimental effect on the driven machine or its product. The inconvenience of a cumbersome system of belts or ropes has usually to be borne in such cases, but it is not too much to say that the requirements of almost all of them are fully satisfied by this type of herringbone gears.

67 The application of spur gears has been much restricted by the noise which they make when run at high velocities. The use of rawhide or other soft materials has only proved moderately successful for comparatively light work and is quite unsound for heavy gear practice. Herringbone gears in combination with durable steel pinions make less noise than soft pinions and spur gears when new, and while the former become quieter with use, the latter soon begin to rattle as they become worn. It should be noted that the use of soft pinions, while mitigating the nuisance of excessive noise, does not reduce vibration or unevenness of motion.

68 There is a limit to the pitch-line velocities at which spur gears can be operated beyond which it is unsafe to use them. This limit is far below the minimum velocities which can be used in connection with steam turbines of economical design and high power.

69 Accurate herringbone gears operate quite smoothly at velocities which are impossible for other types. This feature would appear to reserve for them a field of application which has great possibilities and is likely to cause some great changes in the standard practice of today.

APPLICATION TO STEAM TURBINES

70 There are many instances when the power of the turbine can be more conveniently applied in mechanical form than through electrical transmission. The advantages of high-power turbines have been discounted in many instances by the necessity for expensive electrical outfits with their attendant losses of generation, distribution and conversion.

71 Direct-connected steam turbines for marine propulsion have been only partially successful in a very limited field. The screw propeller, working in a dense medium, has an economic speed of rotation which is far below the best speed for a steam turbine of corresponding power. It is only when the power required is very great and the speed of the vessel unusually high that the direct-connected turbine can be applied, and even then the application does not do full justice to either turbine or propeller, while the first cost is much higher than it need be. The use of direct-coupled turbines is confined to ocean fliers and ships of war. Ordinary vessels of commerce, which are built in vastly greater numbers, cannot be adapted to turbine power in this form. Mr. Parsons attacked the problem of applying the turbine to an ordinary freight steamer of moderate power. To

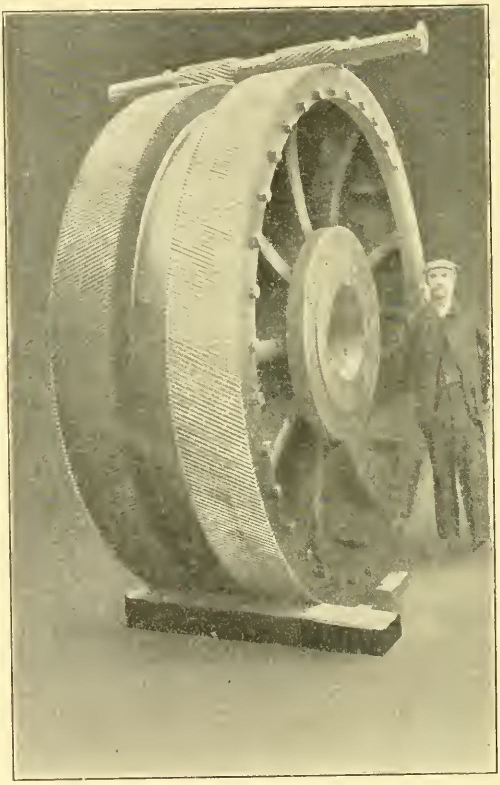


Fig. 8 Gear and Pinion for 500-h.p. Marine Turbine

this end he purchased the S. S. Vespasian, a modern tramp with triple-expansion engines of about 1000 h.p. and a speed of 11 knots with propeller running at 75 r.p.m. As a preliminary to the installation of geared turbines on this vessel, the original engines were overhauled and tuned up and a series of coal consumption trials made under regular sea-going conditions.

72 The engines were then removed and for them were substituted a pair of steam turbines connected to the propeller by the herringbone gears illustrated in Fig. 8. Each turbine develops about 500 h.p. at 1500 r.p.m. The propeller runs at the original speed of 75 r.p.m. Each turbine is coupled to a herringbone pinion with teeth cut solid on a shaft of soft-grade chrome nickel steel. The two pinions mesh with rolled-steel gear rings mounted on a cast-iron spider which is keyed to the propeller shaft. The whole gear system is enclosed in a case, and the teeth are kept lubricated by oil jets. The great width of the pinions in proportion to their diameter made it necessary to provide room for bearings between the right and left-hand teeth. The proportions of this remarkable gear unit are as follows: Pinions, 20 teeth; gear, 398 teeth, 4 diametral pitch; teeth of involute form, 20 deg. pressure angle, 23 deg. spiral angle; over-all face width, 34 in. including 10 in. space for bearing; actual face width, 24 in.; ratio of reduction, 19.9 to 1.

73 This gear has now been running regular voyages for more than a year and has covered over 20,000 miles. The results have been interesting and satisfactory. The efficiency of the gear is fully 98 per cent, including the losses in the bearings on the gear case. The geared turbine shows a sustained all-round saving in fuel consumption of more than 25 per cent over the original engines. The gear runs with remarkable smoothness and without noise or vibration. The wear on the teeth is negligible after 20,000 miles, being only 0.002 in. at the pitch lines of the pinions. Even this small wear is nearly all traceable to inadequate arrangements for freeing the oil from grit during the first runs.

74 Not by any means the least important gain is in the behavior of the vessel in rough water. There has been no racing of the propeller under circumstances where this disagreeable feature was painfully evident with the original installation. This is due to the high rate at which the turbine motors store up energy with change of speed, which makes it impossible for a large change to occur during the time when the propeller is partially uncovered. Such a record as this is so conclusive that the use of geared turbines for marine pro-

pulsion must shortly become general. Herringbone-geared turbines aggregating 3600 h.p. have recently been fitted to the U.S.S.S.Neptune by the Westinghouse Machine Company. The performance of this vessel will be awaited with interest.

75 Mr. Parsons has made a successful introduction of herringbone gears in combination with a steam turbine for driving a continous plate mill. This is a proposition which few engineers would have considered seriously, yet it has proved a success from every point of view.

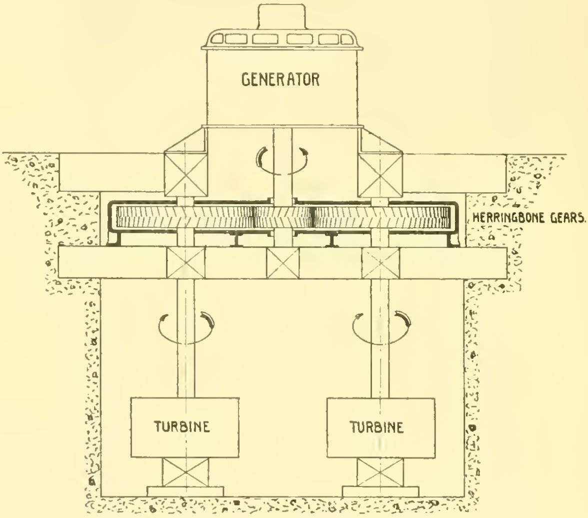


Fig. 9 Diagram of Gear Connection between Hydraulic Turbines and an Electric Generator

76 The mill is of the three-high type with rolls 28 in. by 84 in. running at 70 r.p.m. The turbine is designed for mixed pressure, running at 2000 r.p.m. with exhaust steam at 16 lb. absolute or live steam at 60 lb. absolute and giving 750 b.h.p. The turbine is coupled to the rolls through a double train of herringbone gears. The first train consists of a chrome nickel steel pinion, cut solid on its shaft and cast-steel gear. Pinion and gear have 25 and 131 teeth, $3\frac{1}{2}$ diametral pitch by 24 in. face. This train reduces from 2000 to 375 r.p.m. and is coupled to the second train through a flexible coupling. The second train includes a high carbon steel pinion of 23 teeth and cast steel gear of 127 teeth, 2 in. circular pitch by 16 in. face. This train reduces from 375 to 70 r.p.m. The final gear is overhung on the

end of a flywheel shaft 22 in. in diameter, which carries a flywheel of about 100 tons between two bearings and is coupled to the main pinion through a pair of wobblers. Both sets of gearing are enclosed in casings and are lubricated by oil jets from a pump provided for the purpose. This mill has been running without a hitch of any kind since September 15, 1910. The gears are noiseless, the installation shows remarkable efficiency, the rolls run with extreme smoothness and the pinions do not show appreciable wear.

77 The success of the geared turbine for such an application as the one described makes it certain that similar arrangements can be used with advantage for driving textile and other mills where the conditions are less severe. The geared turbine is making rapid progress for driving direct-current generators, and several large sets are now running and in course of construction.

78 Hitherto, it has been usual to couple the turbine to a high-speed alternator and to convert to continuous current through a motor generator or rotary converter. The geared turbine unit costs less money, takes up less space and has an overall efficiency at least 6 per cent better than the A.C.—D.C. combination.

79 Geared turbines have another field of application for driving centrifugal pumps. Direct driven units of this kind have poor efficiency because a compromise has to be made between turbine and pump speed which is detrimental to both. The interposition of a set of herringbone gears allows both ends to be constructed for the highest economy, and since the loss in the gears does not exceed 2 or 3 per cent there is a large all-round gain in efficiency. This applies also to turbine-driven blowers and fans.

GEARED HYDRAULIC TURBINES

80 The speed of hydraulic turbines is controlled by the available head of water supplied to them. The greater number of turbines are required to operate under low heads and must run at slow speed. Hydroelectric power has usually to be transmitted to a considerable distance and is produced in the form of alternating current of definite periodicity. The speed of the turbines may be as low as 50 r.p.m. or even less. A large direct-coupled alternator for this speed is an expensive proposition.

81 Herringbone gears can be used to speed up from the slow-running turbines to generators of normal design, speed and efficiency. The smooth action of these gears is unimpaired when the wheel drives the pinion, and high ratios of speed increase can be obtained from them

without noise and with less loss than direct coupled units will give. A typical installation of this kind is outlined in Fig. 9. This arrangement shows two slow-speed vertical turbines driving one generator. A herringbone gear is mounted on each turbine shaft and both gears mesh with a pinion which is coupled to the generator.

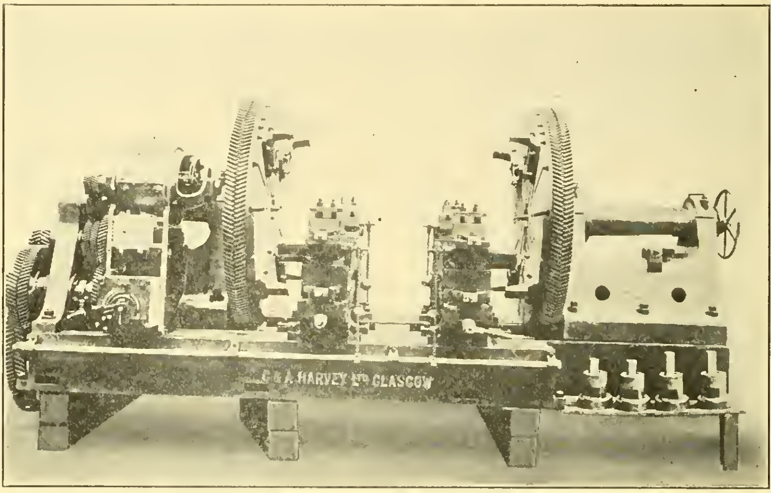


Fig. 10 Tire-Turning Lathe with Herringbone Gears

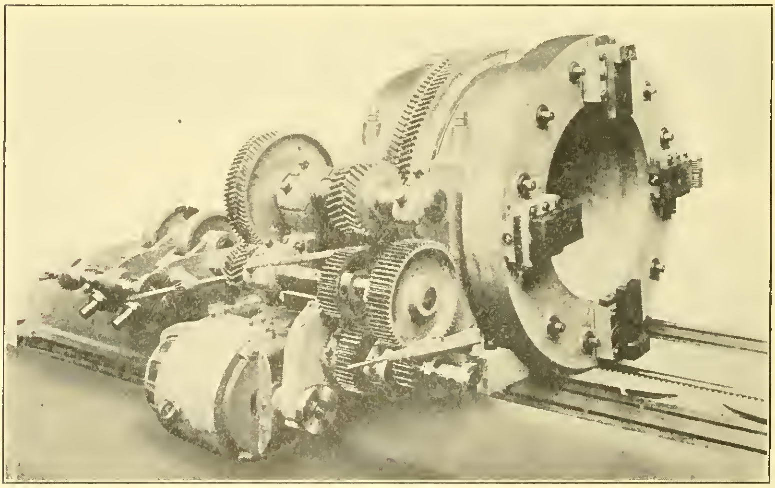


Fig. 11 Gun-Boring Lathe with Herringbone Gears

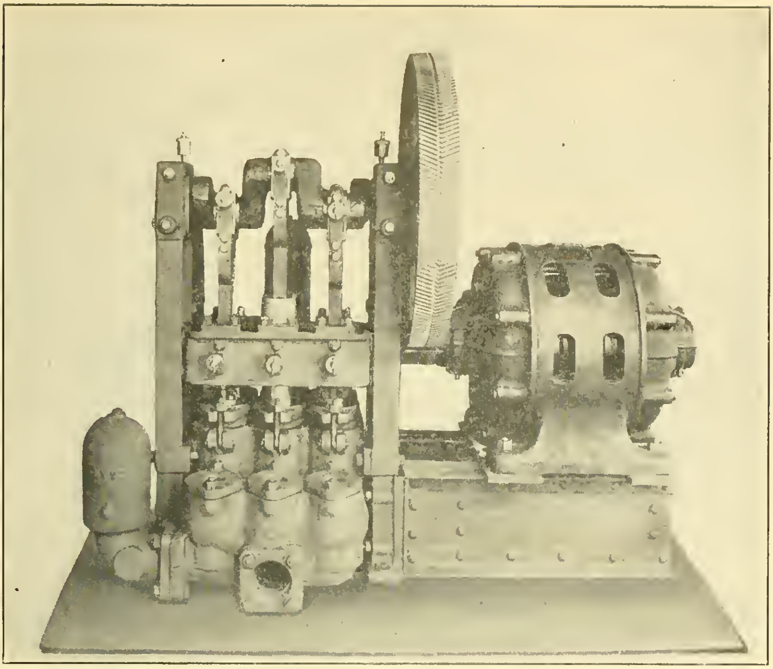


Fig. 12 Herringbone Gears applied to Electrically-Driven Triplex Pump

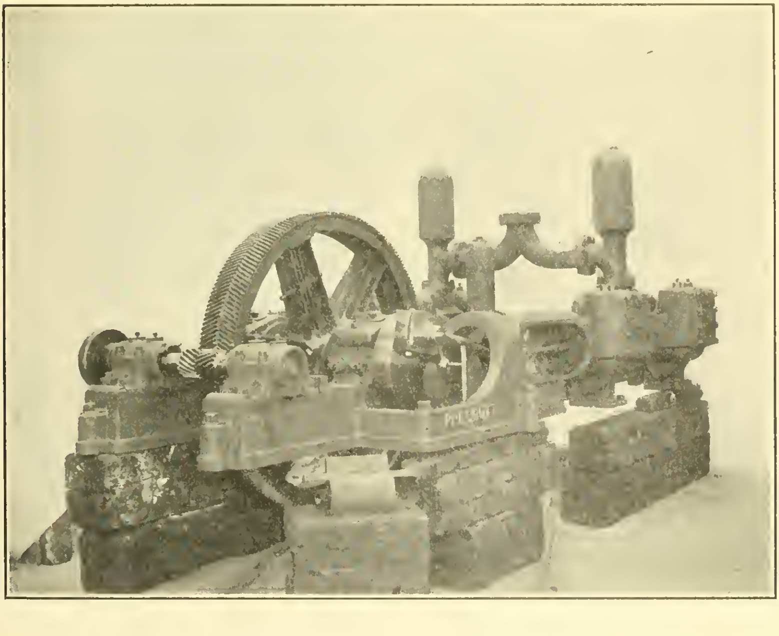


Fig. 13 Gear-Driven Horizontal Pump, Gear Ratio $12\frac{1}{4}$ to 1

ROLLING MILLS AND ROD MILLS

82 There are two advantages in the use of accurate herringbone gears for this class of work. The absence of shock in transmission renders breakages much less frequent than with cut spur or moulded helical gears. The even transmission and entire elimination of vibration allows the finishing rolls to be gear driven for the finest work without showing gear marks on the finished product. Herringbone-geared mills run with very little noise. This may be of less consequence in rolling mills than in most other applications, but it is an improvement. Rod mills, with their quantities of high-speed gearing, can be completely transformed by using herringbone gears and mill pinions.

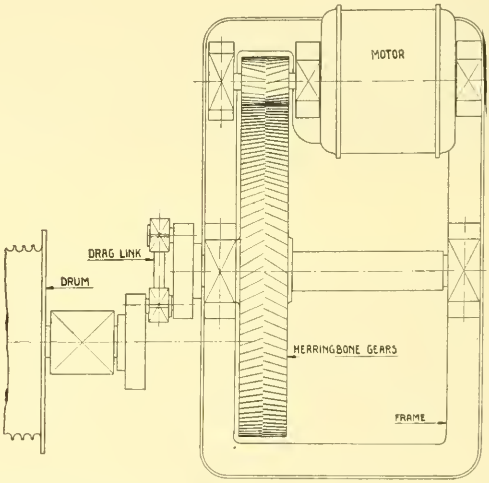


Fig. 14 Electrification of Mine Hoist formerly Steam Driven

MACHINE TOOLS

83 The field for accurate herringbone gears in connection with machine tool driving is too extended to be considered in detail. For individual motor drives this gear gives a positive transmission which is free from vibration and less noisy than so-called silent chains or rawhide pinions, while there is no trouble from slipping belts or slack chains. But the real advantage of these gears lies in the better finish that can be obtained when they are used for the entire main transmission, and in the higher output combined with reduced maintenance which they give to heavy machine tools. Chatter is eliminated. Even the speeding up to the wheels of grinding machines has

been successfully accomplished. Reversing gears for heavy planers are a revelation to those familiar only with the ordinary spur drive. Illustrations of machine tool drives are shown in Figs. 10 and 11.

PUMP DRIVING

84 Electrically-driven plunger pumps have not enjoyed the popularity that might be expected, due to the noise and vibration caused by the gearing between motor and pump shaft. These objections are obviated by accurately cut herringbone gears, which not only give silent and vibrationless transmission but admit the use of high ratio single reductions with compact dimensions. The single reduction drive has a much higher efficiency than the ordinary double train, quite apart from the lower gear losses, because at least one countershaft can be dispensed with. Examples of such drives are

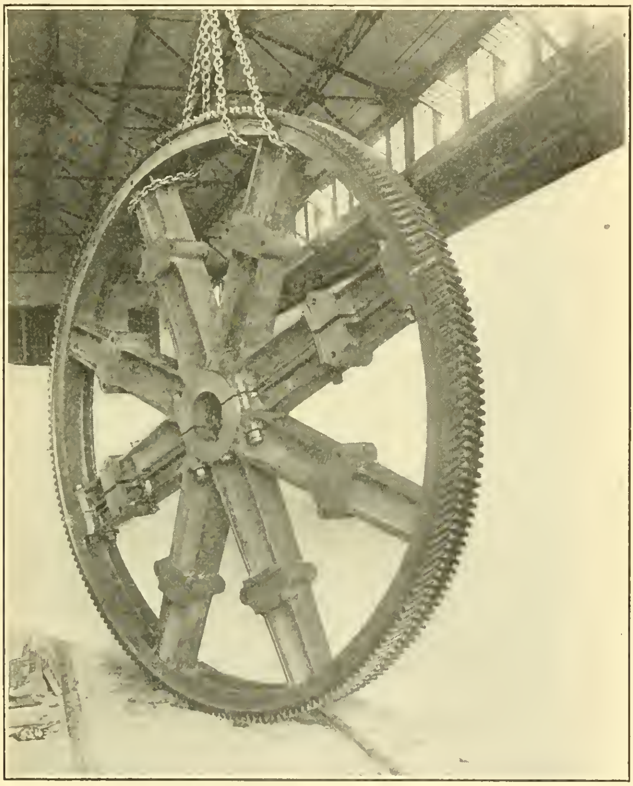


Fig. 15 Semi-Steel Gear, 12-In. Face, 12 Ft. in Diameter, for Mine Hoist

shown in Figs. 12 and 13. Similar drives are successful for air compressors and vacuum pumps which present similar difficulties to those met with in plunger pumps.

APPLICATION TO MINING

85 One of the features in the recent electrifications of the Eckstein group of mines on the South African Rand is a train of herringbone gears between motor and drum in the main hoists. These hoists are driven by reversing asynchronous motors; the geared countershafts being connected to the drums by drag links from the original crank pins that were used when the hoists were run by steam power. The arrangement is shown in diagram in Fig. 14. Fig. 15 shows a large gear made for mining work.

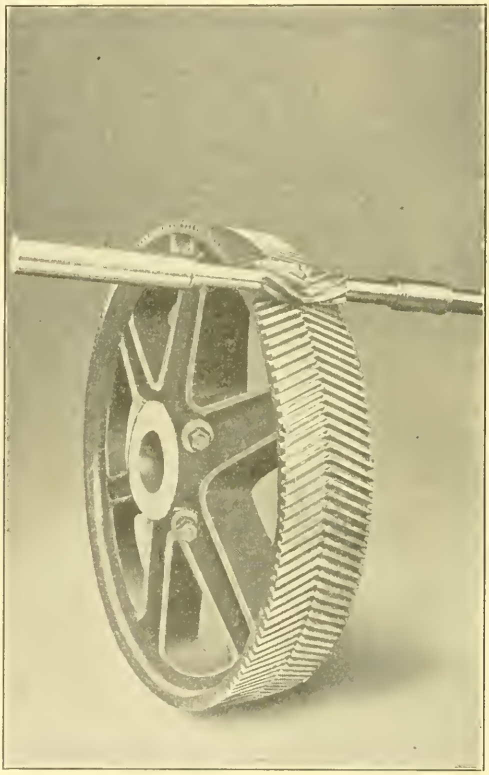


Fig. 16 Typical High Ratio Gear and Pinion, the Latter With 8 Teeth

86 In installations of this type there are no slipping clutches, and

the strains on the gears are very severe, some of them having to transmit 3000 to 4000 h.p. at pitch line velocities ranging from 2000 to 3500 ft. per min. The large coal mines in Northumberland, Yorkshire and South Wales are rapidly adopting high tension three phase current for the distribution of power below ground. Some very large main and tail, and endless, haulages are used in these and herringbone gears have become a standard for this class of work. The hoists range from 30 h.p. up to 1000 h.p. and invariably use a high reduction with ratios which are sometimes as high as 15 to 1. Simplification of design and saving of space is obtained in this way, since ordinary spurs require a double train. The gain in efficiency and absence of noise are remarkable, while the first cost of the whole outfit is often less than when cheaper gears are used. The elimination of all vibration prevents crystallization of the shafts and disintegration of the insulat-

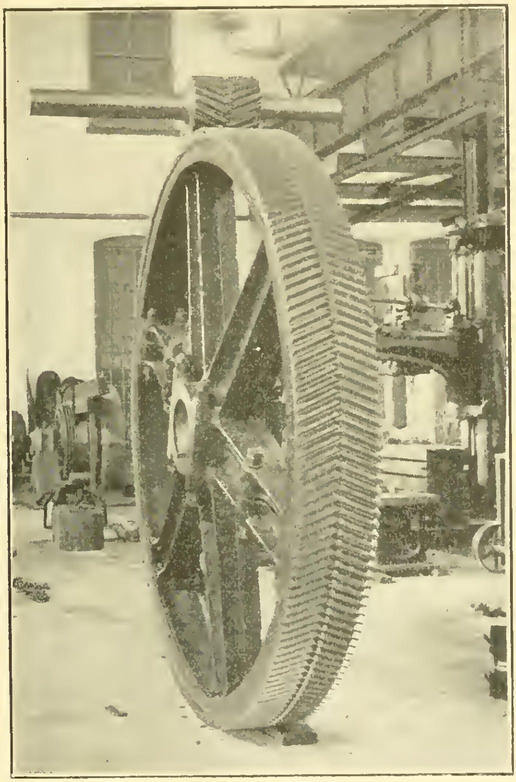


Fig. 17 High Ratio Pump Gears, Gear 9 Ft. in Diameter

ing material in the motors. These gears offer the same advantages for endless haulages. A higher speed motor can be used when they are adopted, while no more than two trains of gears are required.

87 An application of especial interest is for driving tipplers. These gears for this purpose have replaced worm gears because they stand up to the heavy strains without excessive wear. The available space for the gears is always limited in such cases. Some typical high ratio gears are shown in Figs. 16 and 17.

ELEVATORS

88 There are very few high buildings in Europe and the elevators there run at comparatively low speeds. As a consequence, worm gears predominate there for this class of work. The Wuest type of gear was brought out with a view to overcoming the losses inseparable from worm gears with high ratios. The needs of American skyscrapers have caused the development of elevators in this country to run on different lines, so that the popular type of today has the rope sheave direct connected to the motor. Needless to say the motor runs at exceedingly slow speed, usually not more than 50 or 60 r.p.m. as a maximum. Such a motor is expensive and inefficient. The system of control is wasteful to a degree. Field regulation is out of the question, and the speed control is obtained by shunting the main current through a resistance so as to reduce the volts across the armature of the motor. The survival of so uneconomical a type of machine is due to there having been no satisfactory gear system which would fit the peculiar conditions. A number of elevators are now being equipped with herringbone gears. The motor is geared to the sheave through a single train with a ratio of about 10 to 1. The maximum motor speed is about 500 r.p.m. and the speed control is nearly all obtained by simple field regulation. The following advantages are claimed: The power consumption is not more than 60 per cent of what is required for direct connected motors, the electrical switchgear is far more simple, has less to do and is not so liable to get out of order; the motor can be repaired without interfering with the car or its suspension.

The Falk Company, Milwaukee, Wis., has acquired the sole rights for the United States under the Wuest patents and during the past year have been constructing some of the most powerful gear-cutting machinery in existence with a view to securing the required degree of accuracy in the production of gears of this type.

GAS POWER SECTION

THE GAS POWER FIELD FOR 1911

By Robert H. Fernald, Mem. Am. Soc. M. E.[1]

Chairman for 1911

The past year of the Gas Power Section has been one of continued prosperity. The progressive policies pursued by the Executive Committee and the various technical committees during the four short years since the birth of the Section have placed it definitely on a basis that assures its future. The reason for its being and the firm belief in a large future for the organization are readily understood by reviewing briefly the steady, healthy development of gas power during the past year—a year that places gas power for large units well beyond the uncertainties of the purely experimental period.

LARGE GAS ENGINE UNITS

The development of large gas engine units has gone steadily forward for the past decade. The first engine of this class was that exhibited by the John Cockerel Company at the Paris Exposition in 1900. This was an engine of 600 h.p. rating. At the present time 1500 h.p. in each cylinder of the 4-stroke cycle type and 2000 h.p. in each cylinder of the two-stroke cycle engine are reported as one of the exhibits at the recent exposition at Brussels. This means units of 8000 h.p. of the twin-tandem double-acting type. The present status of the large blast-furnace gas-power plants has been ably and thoroughly presented at recent meetings of this Section, and the papers and discussions form a valuable portion of the proceedings of the Society.

It is understood that at least one company is prepared to install gas engine plants of large power capacity at a cost not exceeding and in some instances less than that of the corresponding steam turbine installations.

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[1] Address of the retiring Chairman read at the Annual Meeting, December 1911.

MARKED STRIDES IN THE DEVELOPMENT AND APPLICATION OF THE DIESEL ENGINE

Although the steam turbine has superseded the reciprocating steam engine for electrical development in central station work, and will probably hold the field for some time to come, it is interesting to note that the Diesel engine, owing to its great success in small station work, is looked upon seriously as a possible rival to the steam turbine within a short time. In a paper recently presented before the Municipal Electrical Association at Brighton, England, the relative cost of a 10,000-kw. installation for steam turbines, gas producers and engines, and Diesel engines, was discussed at length. The author's proposition was to use seven sets each of 1450 kw. capacity. His figures of operating expense, etc., are decidedly in favor of the Diesel engine installation.

Attention was also called to the very economical use of these engines as a substitute for substation converting machinery. Such stations are already putting in their appearance in London.

In this connection it is interesting to note the development in point of size of the Diesel engine. Engines of a few hundred horsepower have become European practice. In Swiss electric stations Diesel engine units of 2000 h.p. are now in use, and one writer on the subject states that the development of the large sized Diesel engine has been so successful that it will not be long before 1000 h.p. developed in one cylinder will be thought nothing extraordinary. One company of world-wide reputation is at present considering more than 2000 h.p. in the single cylinder of Diesel engines. It is stated that engines of this type with four cylinders developing 1000 h.p. each can be made as light as the corresponding triple expansion steam engine.

The weight of such engines compares favorably with that of the corresponding turbines and boilers. It is understood that a 1000-h.p. installation of this type weighed only 187 lb. per h.p. as compared with 180 lb. for a steam turbine and boiler installation.

The crude oil engine is now definitely under consideration for all types of marine craft. For small vessels the advantage lies in the safety afforded by the use of crude oil as compared with lighter oils. The crude oil engine is being used by many of the principal navies of the world for submarine boats, and designs are already under way for comparatively large engines for torpedo boats and similar craft.

A few months since, the Vulcanus, a vessel of 1900 tons displace-

.nent, 196 ft. long, equipped with 6-cylinder 4-cycle single-acting reversible Diesel engines, was put in regular service between Holland and Borneo. This engine is about 500 b.h.p. capacity at 180 r.p.m. The fuel is a crude oil from Borneo and the quoted guarantees are 0.42 lb. per b.h.p-hr. at full speed; 0.44 lb. at three-quarters speed; and 0.5 lb. at half speed. In a recent trip the Vulcanus covered 3312 miles in 19 days and 3 hours. The average speeds varied from 6.86 knots to 7.80. It is understood that the average consumption for this ship amounts to 1 ton of fuel oil per 100 knots.

The technical journals of recent date record many such installations. Among these Russia is credited with at least four freight vessels of 1000 h.p. and two 14-knot gunboats of the same horsepower rating.

This month two vessels nearly 400 ft. long of 7000 tons capacity, each fitted with Diesel engines of 2500 h.p. rating, and with two auxiliary Diesel engines aggregating 500 h.p., will be tried out in European waters.

A recent announcement is to the effect that the Hamburg-American Company propose to build an ocean liner using oil engines for motive power.

In this connection attention is especially directed to the most recent development in the oil engine field—the Junkers marine oil engine. These engines for the freight vessels of the Hamburg-American Line, are of the twin-tandem type of 1600 total shaft h.p. each. The engines operate on the 2-cycle principle, and through the introduction of two pistons into each cylinder double action is secured.

An interesting comparison will shortly be placed before the public by the British Admiralty, as it is proposed to try out side by side in a twin screw cruiser a steam engine and a Diesel engine of 6000 h.p. rating.

Another destroyer recently ordered by the British Admiralty, according to current reports, will have on each shaft a steam turbine and a Diesel engine. The plan is to operate the turbines when high speeds are required, but under cruising conditions, when the speeds are low, owing to the poor economy of the steam turbines, the Diesel engines will be used. The combined economy due to this arrangement will be exceedingly interesting.

One of the interesting features of these engines is the fact that there seems to be a marked tendency toward the 2-stroke cycle for marine work.

With the introduction of these engines the discomforts of the stoke hole will be greatly reduced, and the amount of labor required will be less than under present marine conditions, and the character of labor much improved.

Although it is not probable that steam installations are to be rapidly displaced in the larger ocean going craft, yet the crude oil engine seems to be especially adapted for such service as that previously indicated. The fuel needed approximates a third of that required for the steam engine, thus greatly increasing the radius of action if the same weight of fuel be carried. Boilers can be done away with and their space utilized for carrying cargo.

It is reported for a freight vessel of 2700 tons that a saving of over $19 per day was made by using oil at approximately $11 per ton, instead of coal at about $3 per ton.

TAR AS A FUEL FOR DIESEL ENGINES

Tar oil has become more or less common as a fuel in Diesel engines of 600 or 800 h.p. rating, and it is understood that it is used in at least one engine of 4000 h.p. rating. Recent experiments indicate that both thin gas retort tar and thick coke oven tar can be used in a similar manner by injecting into the cylinder a small percentage of light oil to assist in igniting the tar. It is claimed that a wide range of tars can be used in this manner without producing smoke or appreciable residue. In tests at the Koerting works about 2 per cent of the ignition oil was used at full load and about 13 per cent at half load. Reports indicate that an order has been placed for a 600-h.p. Diesel engine to operate on raw tar.

INTERNAL-COMBUSTION ENGINE LOCOMOTIVES

Locomotives using internal-combustion engines and operating on the standard gage track have recently been put into service. The range of fuel for these engines covers gasolene, benzol, alcohol and petroleum.

The Prussian State railways are reported to be operating a 1000-h.p. locomotive using a Diesel engine as motive power.

GAS TURBINE

Results are soon to be expected from the more recent investigations and tests relating to gas turbines. It is believed that some of the types are based on correct principles, and that after a rotary air compressor of satisfactory design has been secured rapid progress in the development of this prime mover may be expected.

RECOGNIZED RELIABILITY OF INTERNAL-COMBUSTION ENGINES

Not only do the renewed and increased orders for internal-conbustion engines by the great manufacturing corporations indicate a feeling of assured reliability, but the subsidizing by European war departments of petrol motor Lorries indicates a feeling of reliability in the internal-combustion principle that is beyond dispute. These vehicles will be held subject to purchase in case of need by the war department. An important stipulation is: "The engines must be of the internal-combustion type using petrol, and by preference having four cylinders."

THE HUMPHREY PUMP

This internal-combustion pump has been before the gas power public for two or three years past. Many similar internal-combustion pumps are clamoring for admission to the field. The comptroller, in discussing the validity of the Humphrey patents, states "The Humphrey pumps show an important advance in the art. Although many applications have been filed for patents since 1858 none has embodied the principles of the Humphrey pump."

The 1000-h.p. pump occupies about the same space as the tandem double-acting gas engine of the same power.

Mr. Humphrey says: "With the compression pressure of 11 atmospheres absolute the theoretical thermal efficiency of the cycle is 52.5 per cent, whereas that of the Otto cycle is only 40 per cent when all corrections for varying specific heats are allowed for. With very moderate compression, under 50 lb., an actual thermal efficiency of 23 per cent has been obtained on a 4-cycle Humphrey pump. This corresponds to 0.95 lb. of anthracite per hydraulic horsepower hour, and was obtained on a lift of only 35 ft."

ILLUMINATING GAS FROM SEWERAGE

A report is current to the effect that the municipality of Bruss, Austria, is to convert the solid residue from the town sewerage into illuminating gas. The figures reported indicate that 1 lb. of solid residue is secured from 60 gal. of sewerage and that 380 cu. ft. of gas are obtained from each 100 lb. of solid residue. The calorific value of the gas is reported as at least equal to and the light better than that of coal gas.

UTILIZATION OF THE WASTE HEAT OF THE GAS ENGINE

Various methods of utilizing the waste heat of the gas-engine exhaust have been attempted from time to time and the demand for such devices for heating buildings has been considerable. Several schemes for accomplishing this result are now commercially in use, but according to recent opinions the most efficient method of utilizing the exhaust is through a combination of gas and steam engines.

Present practice indicates that about 3 lb. of steam are generated per b.h.p-hr. by means of exhaust boilers.

According to Mr. Chorlton the use of exhaust boilers with efficient steam engines and specially designed gas engines of the 2-cycle type will effect marked thermal economies and reduce initial cost of the installation per horsepower.

One of the technical journals states that Mr. Chorlton shows by numerical examples the possibilities of such an engine, first examining the case of the addition of a steam end to a normal economical gas engine. He assumes a standard engine to use 9500 B.t.u. per b.h.p-hr. As the engine is ordinarily arranged with jacket feed to the boilers we may take 40 per cent of this amount to be recoverable. From this at 80 per cent efficiency of conversion at 100 lb. pressure we would recover about $2\frac{1}{2}$ lb. of steam per b.h.p-hr. This amount in an ordinary simple steam engine would not give more than 10 to 12 per cent of the main engine power, a return which hardly justifies the first cost of the steam cylinder. Consequently no development has taken place in this direction.

When, however, we are dealing with a special combined compound engine, each part of which is made in the most suitable way for the purpose required, we get a very different result. In order to reduce the cost of the gas engine part the compression would be lowered, and with the ignition retarded a much lower maximum pressure and temperature would result; the total heat units used would go up to, say, 12,000 B.t.u., but more would be rejected to the exhaust, and with a special arrangement of boiler, economizer pipes, superheaters in exhaust, etc., 50 per cent waste heat should be recoverable. There should be obtained from this 4 lb. of steam per b.h.p-hr.

The steam cylinder used would be similar in type to that of the 2-cycle engine, that is, with no exhaust valves. The unidirectional flow engine of this type has been largely re-introduced in Germany with very economical results. The jacketing of the ends could be done by exhaust gas. For small engines of this type it is safe to assume a steam consumption of 12 lb. per b.h.p-hr.; a consumption of 10 lb. has been obtained in actual practice. Hence the power obtained from the steam cylinder would be one-third of that or the gas cylinder, and the consumption for total effective power would be reduced to 9000 B.t.u. per b.h.p-hr., less than that for the economical gas engine alone.

SURFACE COMBUSTION

By what he terms "surface combustion" Professor Bone reports for gas fired boilers evaporations of 21.6 lb. per sq. ft. of heating surface and an efficiency of heat transmission of 94 per cent. The heat balance of a test reported by him shows:

Gas burned per hr. (at 32 deg. fahr. and 14.7 lb.), cu. ft.	997
Net calorific value of gas, B.t.u	562
Total heat supply to boiler per hr., B.t.u	559,800
Temperature of feedwater, deg. fahr.	42
Pressure of steam, lb.	100
Water evaporated per hr., lb.	450.3
Water evaporated from and at 212 deg. fahr., lb.	550
Heat transmitted to water, B.t.u.	450.3 x 1172 = 527,800
Heat ratio 527,800 ÷ 559,800	0.943

In the reports of the surprising results of these investigations attention is called to the fact that the combustion was perfect, as was shown by analysis. An efficiency of 94 per cent was obtained. Deducting 4 per cent for the power required for supplying air pressure still leaves 90 per cent.

Professor Bone says: "The new boilers could be set up in brick work and require no elaborate flues or chimneys. They are liable to no strains as they are short. With some sacrifice of efficiency the evaporation could be raised to 30 lb. per sq. ft. The steam was raised quickly (steam at 100 lb. pressure obtained in 20 minutes from cold start), and tubes could be grouped and cut out separately so as to vary the fuel consumption to suit the fluctuations of load."

In the first foot of the tubes 65 per cent of the steam was generated; 25 per cent in the second foot, and 10 per cent in the third.

PRODUCER GAS FROM LOW GRADE FUELS

Progress is steadily being made in the utilization of lignite, peat, and high ash coals in producer-gas work. The investigations of the Canadian Government show that peat can be prepared for fuel purposes at a cost averaging from 30 to 40 per cent of that of an equivalent B.t.u. value in anthracite in Canada.

As the foundation of a method that may result in extensive use of high ash fuels without prohibitive cost of operation, attention is directed to the present producer-gas investigations of the United

States Bureau of Mines, resulting in the successful fusing of the ash and the use of water-cooled producer linings.

In line with this specific conservation of fuel resources it is interesting to note that one estimate states that the United States Steel Corporation alone, through its installations of blast-furnace gas engines, displaces or saves a consumption of approximately 1,000,000 tons of coal per annum as against the old-fashioned methods.

SMALL PRODUCERS FOR BITUMINOUS COAL

Reports are persistently before us indicating the successful development of gas producers of small power to operate on bituminous coal, coke breeze, anthracite screenings, "front end cinders," etc.

Such plants are in great demand, but it is doubtful whether the development and application have been as great as the advertising these plants receive. It is interesting to record, however, that a company manufacturing anthracite gas producers and gas engines which expressed its firm conviction in 1904 that the Government tests with bituminous coal in producers would fail utterly, recently put itself on record as recommending the use of its own engines with small bituminous producers manufactured by another company.

CRUDE OIL GAS-PRODUCERS

The development of the crude-oil gas producer, for which there is great demand in oil regions remote from the coal field, has been exceedingly slow, but it is believed that very definite progress has recently been made along this line. The most recent notes on this subject relate to the Grine oil producer. In this type steam spray is used for atomizing the oil which is introduced into the upper part of the generator where partial combustion takes place. The downdraft principle is then applied and the hydrocarbon broken up and the tar fixed by passing through a bed of incandescent coke. Mr. Grine reports that a power plant using one of these producers has been in operation a year in California. With crude oil as fuel costing 95 cents per bbl., or 2.3 cents per gal., the plant is reported to develop the same amount of power per gallon of crude oil as is ordinarily developed by the standard internal-combustion engine operating on distillate at 7 cents per gal. Including the cost of fuel, labor, supplies, interest, depreciation and taxes, Mr. Grine states the cost per b.h.p-hr. to be 0.76 cents for a plant of 100 h.p. rating.

The opportunity for investigation in the gas power field is at present unlimited, as is evidenced by the fact that nearly 100 important gas-power problems are at present on file at the United States Bureau of Mines under the head of Proposed Investigations.

It is gratifying to note that each year removes many of the absurd prophecies regarding the elimination of practically all prime movers save the internal-combustion engine, and that the past year may be regarded as one of steady, conservative progress and development in a field that is of keen interest to so large a percentage of the total membership of The American Society of Mechanical Engineers.

FOREIGN REVIEW

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

An Index to Current Articles in Foreign
Periodicals, with Abstracts of Some
of the More Important

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ARTICLES WITH STARS ARE ABSTRACTED MORE FULLY IN PAGES WHICH FOLLOW

Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *a* comparative; *b* descriptive; *c* experimental; *d* historical; *e* mathematical; *f* practical; *g* general; *h* theoretical. Articles of exceptional merit are rated *A* by the reviewer.

AERONAUTICS

EVALUATION DU TRAVAIL DE L'HÉLICE EN FONCTION DE LA FORCE VIVE, L. Legrand. *Revue universelle des mines et de métallurgie*, August. 30 pp., 7 figs. *Ae.*

Contrary to the generally accepted views, the author claims that the *theoretical expression of the work of an aerial propeller* in motion is not ½ Mv^2, but its double, Mv^2. He finds that this analytical calculation is supported by the experiments of Riaboushinsky, and that the coefficient of efficiency of a propeller revolving at a fixed point (fan) is about half that of an aerial propeller in motion.

RÉSISTANCE DE L'AIR APPLIQUÉE À L'AVIATION, J. Chovet. *La Revue de l'aviation et des sports*, October. 2¾ pp., 4 figs., 4 tables. *e.*

The generally used formulæ, *resistance of air* $F = KSV^2 \sin^2 \alpha$, pressure $P = KSV^2 \sin^2 \alpha$, can be used only under certain conditions. The author replaces them by the following formulæ: for angle of α not less than the angle of curvature of the plane β: $F = k0.067 \sin^2 (\alpha + \beta)$, and $P = \dfrac{C \sin^2 (\alpha + \beta) \cos\alpha}{\sin \alpha}$, where k is the ratio between the breadth of the wing and its thickness, and α and $\sin^2 (\alpha + \beta)$ are obtained from tables from Mr. Eiffel's experiments. The author calculates also a resistance R normal to the plane, and finds that it is equal to $\dfrac{C \sin^2 (\alpha + \beta)}{\sin \alpha}$. The article is to be continued. Tables give values of constants and variables used in the formulæ.

AIR MACHINERY

CALCUL DES COMPRESSEURS CENTRIFUGES, Ch. Lemale. *La Technique moderne*, November. 3½ pp., 8 figs., 3 curves. *e.*

Discusses the theoretical bases, and gives mathematical methods for the *calculation* of orifices *for piston and multicellular compressors*, of output, pressure, and of shafts, rigid and flexible, giving a graphical method for the calculation of a rigid shaft with two supports.

TRYCKLUFTLOKOMOTIF FÖR MALMTRANSPORT, A. Thunblom. *Bihang till jernkontorets annaler*, November. 3 pp., 1 fig. *b.*

Description of a *compressed-air locomotive for transportation of ore* built by the Nya Actieboglaget Atlas in Stockholm. The following data were obtained: Consumption of air about 5m.^{3} per ton-km. ore (109 cu. ft. per ton-mile); cost of consumed air about 7.5 öre per ton-km. ($0.02 per ton-mile), since 1m.^{3} of air compressed to 6 to 7 kg. per cm.^{2} (85.2 to 99.4 lb. per sq. in.) cost 1.5 öre ($0.004); the compressed-air locomotive can be conveniently used at a speed of 6 km. (3.7 miles) per hr., but can be driven at 9 to 10 km. (5.6 to 6.2 miles) per hr. on a straight track.

CASE-HARDENING

LA CEMENTATION DU FER PAR LE CARBON SOLIDE, Charpy and S. Bonnerot. *Revue des métaux et alliages*, November. 1½ pp., 1 table. *C.*

Paper before the French Academy. Guillet and Griffiths have found that *solid carbon* does not produce any *case-hardening* of iron in a vacuum, while Weyl has found that it does. The present authors show that all depends on what degree of vacuum is maintained. When the pressure was under 0.1 mm. of mercury, the iron remained for 38 hours in contact with carbon at a temperature of 950 deg. cent. (1742 deg. fahr.) and no case-hardening occurred, but when the pressure was allowed to reach 0.5 mm., a very clear case-hardening was developed.

CRANES

MÂT-GRUE À ROTATION TOTALE, P. B. *Portefeuille économique des machines*, November. 5 pp., 13 figs, 3 sheets of drawings. *Ab.*

Description of a *mast-crane* (Louis Perbal and Co. system), arranged to make a complete revolution. The mast carries on its top a slewing crane with a hook for carrying the load, the driver's stand with the lifting gear and motor being placed at about one-third of the height of the mast.

CRUSHING MACHINERY

GROUPE DE MOUTURE "ORION," M. Bousquet. *Portefuille économique des machines*, November. 1½ pp., 5 figs. *Ab.*

Description of the "*Orion*" *crusher*, consisting of a ball-mill without a sieve and an air separator. The sifting is done in a separate apparatus outside the crusher, and this enables the ball-mill to do an amount of work which formerly, as the author says, would be considered impossible.

FUEL

LE BENZOLE VA MANQUER, M. Miguet. *La Pratique automobile*, November 10. ½ p. *b.*

Benzene, being a product of distillation of coal, cannot be counted upon as a fuel for automobiles, owing to its limited output.

ZUR FRAGE DER GASFEUERUNG IN GEWERBLICHEN UND INDUSTRIELLEN BETRIEBEN, Director Förster. *Journal für Gasbeleuchtung*, November. 1 p., B curves. *f.*

An investigation made for the design of a packing-house in Mühlheim-Ruhr, Germany, has shown that at a price of 4.3 pfennig per cu. m. ($0.30 per 1000 cu. ft.) *gas is just as economical as coal* for heating two flue boilers of 50 sq. m. (538 sq. ft.) heating surface each, and that even a slight excess of this price would be compensated for by the absence of smoke, soot and dust. Curves show relative cost of coal and gas fuels.

TECHNIC UND INDUSTRIE AUF DER INTERN, HYGIENE-AUSTELLUNG IN DRESDEN. *Dingler's Polytechnisches Journal*, November 25. *b*.

Lignite briquettes are produced in the following manner by the Verein der Niederlausiter Braunkohlenwerke N-L., Germany. The lignite is first broken by rollers and then ground to powder; the powder, containing 50 per cent to 60 per cent of water, is dried in tube or disc driers, being heated by exhaust steam, until it contains not more than 12 per cent to 15 per cent of moisture, is passed through a sieve and finally submitted to a pressure of about 1500 atmospheres (kg. per $cm.^2$), without the use of any binding substance. The output of a press is about 150 tons of briquettes in 24 hours. By this process the calorific power of the raw lignite equal to 2000 to 2500 W.E. (= 8000 to 10,000 B.t.u. in round figures), is raised to 4700 to 5100 W.E. (= 18,800 to 20,000 B.t.u. in round figures) in the briquettes.

CONTRE LA COMBUSTION SPONTANÉE DES CHARBONS. *L'Echo des mines et de la métallurgie*, November 23. *b*.

Mr. Razous has presented a paper to the French Society for the Advancement of Sciences, in which he recommends the following measures for the *prevention of spontaneous combustion of coal:* (*a*) if coal has to be kept for more than two months, it is well to keep only washed coal; (*b*) if non-washed coal has to be kept, it is a good plan to place in the heaps, at a certain distance from each other, temperature-registering appliances for detecting any rise in temperature; (*c*) if an abnormal rise of temperature is discovered in unwashed coal at the mine, the coal should be washed at once; if the same happens in a manufacturing plant, the heap ought at once to be turned over by shoveling, to reduce the temperature.

GAS PRODUCER

*FORTSCHRITTE UND NEUERUNGEN AUF DEM GEBIETE DER GASGENERATOREN, Gwosdz. *Die Gasmotorentechnik*, November. 3pp., 3 figs. *d*.

Historical sketch of the development of the *gas producer*, mainly with regard to its ability to use cheaper kinds of fuel. Contains a description of the Morton gas producer and the gas producer for suction gas engines of the Société Française de Matériel Agricole et Industriel in Vierson, using for fuel agricultural waste materials such as straw, wood and chips.

INTERNAL-COMBUSTION ENGINES

LES TROIS CYLINDRES ANZANI, TYPE MILITAIRE. *L'Aérophile*, November 15. 1 p., 2 figs. *b*.

Description of the new *Anzani 3-cylinder motor* adopted for the military Bleriot airships. The Anzani carburetor is placed above the motor and feeds a gas bag placed at the back of the casing. Into this bag are also led aluminum tubes from the cylinders. The tubes are placed just behind the cylinders in order to protect them from the cold and wind. The lubrication is through the interior of the flywheels and crankpin, by pressure from a pump driven by the motor. The cylinders, pistons and many other parts can be interchanged with corresponding parts of the 6-cylinder Anzani motor, military type.

MITTEILUNGEN DER LUFTSCHIFFBAU ZEPPELIN FRIEDRICHSHAFEN, Graf. v. Zeppelin. *Zeits. für Flugtechnik und Motorluftschiffahrt,* November 11. 6 pp., 17 figs. *b.*

Description of the 150-h.p. *Mayback motor* and methods of testing it.

NOS MOTEURS SONT-ILS PERFECTIBLES? M. d'About. *Technique automobile et aérienne,* November. 2½ pp. *g.*

The progress of metallurgy will help the future designer of internal-combustion engines by supplying him with better materials, but, although the author says that he has seen a motor going without vibrations at 5000 revolutions in a vacuum, he believes that the limits imposed by the limitations of the diameter, lift and number of valves will be impossible to overcome. The increase of efficiency of the engine can be attained by enriching the mixture, but the author does not believe that this can be done by injection of water, as Mr. Patrouilleau tried to show in a paper extensively quoted in this article.

*DIE DIESEL MASCHINE DER MASCHINENFABRIK, J. E. CHRISTOPH ACTIENGESELLSCHAFT IN NIESKY O-L., AUF DER POSENER AUSTELLUNG, 1911. E. Neuberg. *Die Gasmotortechnik,* November. 3 pp., 5 figs. *b.*

Description of the *Diesel engine* manufactured by the above named concern, including an interesting description of the *system of standardization used in the production of the engines.*

*UN MOTEUR ALTERNO-ROTATIF RÉVERSIBLE, F. Carlès. *La Technique automobile et aérienne,* November. 1½ pp., 4 figs. *B.*

Description of a motor invented by Louis Brun in which the *reciprocating motion of the piston is directly transformed into a continuous circular motion.*

LE LAMINAGE DANS LA DISTRIBUTION DES MOTEURS, A. Guéret. *La Technique automobile et aérienne,* October, November. *a.*

The author finds that the *piston engine without poppet valves* (such as the Knight motor) possesses the following *advantages* as compared with the classic type: mechanical and continuous admission without shocks; well balanced valve gear; possibility of using high compressions; higher thermal efficiency, and possibility of using higher speeds of rotation. The disadvantages are: novelty of type; delicate system of lubrication; necessity to take care of possible leakages and expansion.

DREHSCHIEBERMOTOR, J. Lorback. *Der Motorwagen,* November 20. 1 p., 4 figs. *d.*

The author maintains that he has long ago (1904?) not only designed but constructed and used for a whole year on his motorcycle a *rotary slide valve motor.* The drawings in the article refer to a 4-cylinder motor, although the machine actually used had only one cylinder.

*CARBURATEUR SUPPRIMANT LE NIVEAU CONSTANT. *La France automobile et aérienne,* November 18. 1 p., 2 figs. *b.*

Description of Rebourg's *floatless carburetor.*

*LE MOTEUR DA COSTA À CALOTTE DE DISTRIBUTION ROTATIVE. *La Pratique automobile,* November 10. 1½ pp., 1 fig. *b.*

Description of the Da Costa *motor with a hemispherical cylinder head and a rotary slide valve rotating against it.*

LE MOTEUR KOERTING-DIESEL HORIZONTAL. *Electro*, October. 2½ pp., 3 figs. *b.*

Description of the *Koerting-Diesel horizontal motor.* It is a 4-stroke, single-acting motor, with slow combustion under constant pressure, and amount of fuel introduced in proportion to the power developed. The escaping gases are invisible and without odor. There is no possibility of the motor exploding. As fuel, cheap and slightly inflammable oils are used, such as unrefined mineral oils, shale-oil, mazout and tar-oil from gas works. The thermal efficiency was found to be 34 per cent and the price per horsepower at half load 1.32 centime ($0.25) and at full load 1.12 centime ($0.21).

MACHINE SHOP

VERGLEICH DER COMBINIERTEN WERKZEUGE GEGEN EINFACHE WERKZEUGE IN STANZEREIHEN, M. Beckman. *Zeits. für Electrotechnik und Maschinenbau*, November 23. 1½ pp., 1 fig., 1 table. *a.*

Comparison of general efficiency of *cutting, punching, etc., by one machine, and doing each of these operations by a separate machine.* The first is cheaper, more speedy and gives better results. Schedule form for calculating cost of production with various forms of punching machinery is given.

VERZAHNUNGSPRUEFER, M. Kroll. *Werkstattechnik*, November. 3 pp., 6 figs. *b.*

Description of an *apparatus for testing toothed wheels* indicating the kind, amount and location of irregularities in the teeth and especially adapted for testing wheels running at high speed. The scheme of the apparatus is as follows: Two bodies, each having a toothed wheel attached to it, are driven from the same shaft by two toothed wheels on a shaft. The wheels on the shaft and that on one of the bodies are perfectly cut, while attached to the other body is the wheel under test. If the wheels on both bodies are perfect, the bodies will rotate with an equal speed and a suitably arranged pencil will draw a straight line, while if the wheel under test has some irregularity the bodies will move at that point with unequal speeds and the pencil will draw a wavy line.

*DIE SELBSTSTÄTIGE ZAHNRÄDERSCHLEIFMASCHINE VON MAYER UND SCHMIDT IN OFFENBACH, a. M. Nickel. *Zeits. des Vereines deutscher Ingenieure*, November 25. 2 pp., 2 figs. *b.*

Description of an *automatic machine for grinding toothed wheels.*

NOUVEAU MARTEAU À RESSORT AJAX. *La Métallurgie*, November 29. 1 p., 1 fig. *b.*

Description of the *Ajax spring hammer*, manufactured by Rudolph Schmidt & Co, Düsseldorf, Germany. It is driven by a belt which can be shifted by a belt fork. The shaft placed behind the frame of the hammer carries at its upper end a heavy flywheel regulating its motion. In the middle of the shaft is placed an eccentric arranged so that its angle of lift can be regulated as desirable, or brought to zero, in such a manner that the big hammers may be used for forging small pieces. In the most recent type the ends of the spring do not pass through an opening in the hammer itself, but through a separate opening covered by a cap cast in one piece with the hammer. This makes the hammer stronger and prevents rupture at that point. On this cap is placed a lubricator cap which insures better lubrication and makes the wear at the opening less rapid. The anvil is not cast in one piece with the anvil-block, but is attached to it by four long bolts.

Die moderne Schleif-und Polierwerkstatt, Eugen Werner. *Werkstattstechnik*, November. 5 pp., 1 fig. *b.*

Description of a *German modern grinding and polishing shop*, with data on installation costs and the cost of using various polishing materials.

MATERIALS OF CONSTRUCTION AND TESTING OF MATERIALS

Ueber den Zuverlässigkeitsgrad von Festigkeitsversuchen, A. Martens. *Mitteilungen aus dem Königlichen Materialprüfungsamt zu Gross-Lichterfelde West*, Vols. 5 and 6, 1911. 95 pp., 3 figs, over 80 pp. of tables. *Ah.*

A. Martens, who is the director of the Prussian Royal Laboratory for the Testing of Materials of Construction, and author of an important book on that subject, discusses *methods of selecting reliable values for the strength of materials* from among several values obtained in different tests, or by different testing laboratories.

L'Aphégraphe, M. R. Guillery. *Mémoires de la Société des Ingénieurs Civils de France*, August. 15 pp., 8 figs., 1 plate of photoengravings. *b.*

Description of two new *apparatus for testing the strength of materials:* (*a*) a dynamometric ram impact machine the purpose of which is to break, by bending by shock, at a convenient speed, a notched test piece of a type defined by the last convention of the International Society of Methods of Testing, and to measure the amount of work required for this fracture; (*b*) the Aphegraphe for tracing curves representing such values as the stress during the shock in the bending test, inertia stresses in certain machines, resistances of railway trains, as a function of velocity, etc.

Priblishenni sposob boslidu zignutya shtab, Prof. Stephan Timoshenko. *Proceedings of the Technical Section of the Ukrainian Scientific Society of Kieff.* 38 pp., 7 figs. *c.*

An *approximate method of solving problems on bending of bars* without integration of differential equations.

Maschinenfundamente aus Eisenbeton, E. Elwitz. *Zeits. für Dampfkessel und Maschinenbetriebe*, November 23. 2pp., 20 figs. *b.*

A brief description of an improved method of the construction of *reinforced concrete foundations for machinery*, with detailed drawings. The improvement consists in laying an upper and lower round iron grating in the foundation. The article and drawings appeared in *Beton und Eisen*, October 25.

Nouveau procédé de la construction en béton-armé, P. Braive. *La Technique moderne*, November. 2 pp., 3 figs. *b.*

Description of the *Monnoyer & Son method of reinforced concrete construction*, used mainly for constructing vertical walls, smoke-stacks, etc. In this method concrete blocks are used in such a size and form that when put together they give a resistance suitable for the given construction, and, at the same time, enclose between them the reinforcing elements. The article indicates the methods of calculation required in the construction of smokestacks, according to the French regulations for the use of reinforced concrete.

MECHANICS

Versuche ueber die Schwingungen von Kardanwellen, Th. Lehmbeck. *Zeits. des Mitteleuropäischen Motorwagen-Vereins*, Mid-November. 3 pp., 3 figs. *c.*

Experimental investigation of *oscillations in Cardan shafts*. The following practical results were obtained: If the setting of the Cardan shaft is as close to the ends as possible, Stodola's equation can be used for the computation of the critical number of revolutions. The longer the ends of the Cardan shaft are beyond the ball-bearings the greater the oscillations and power losses. Stodola's equation (Die Dampfturbinen, 1905, p. 197) is: the critical number of revolutions $N_k = \frac{r\,10^4}{L^2 1.633}$, where r is the radius of the shaft and L is one-half the distance between the centers of the ball-bearings, both in centimeters. It is further extremely important that the shaft be turned perfectly true, because the slightest deviation leads to a rapid growth in the amplitude of oscillations, and results in a total destruction of the ball-bearings. No Cardan shaft should be made of tubing, because, even with truest turning, it is never so uniform as to prevent the rise of centrifugal forces which produce oscillations, and will lead to an instant breakdown should these oscillations coincide with the critical number of revolutions.

PUMPS

Gaspumpen und Kompressoren, Dierfeld. *Elecktrische Kraftbetriebe und Bahnen*, November 27. 5½ pp., 13 figs. *b.*

A description of the latest type of the *Humphrey gas pump*, based on materials communicated by the inventor, Mr. Humphrey, and a discussion of its characteristics and industrial possibilities. (See also Practical Engineer and Engineer's Gazette, London, August 4, 1911, The Humphrey Internal-Combustion Pumps.) Article to be continued.

*Der Hydropulsor, eine neue hydraulische Schöpfmaschine. *Prometheus*, November 11. 5½ pp., 8 figs. *b.*

Description of a *new hydraulic pump* constructed on the principle of Mongolier's hydraulic ram, but having instead of two poppet valves one rotary valve working without shocks and thus permitting the construction of large units.

REFRIGERATING MACHINERY

NEHEMIA KÄLTEMASCHINEN. *Haustechnische Rundschau*, November. $^2/_8$ p., 1 fig. *b*.

Description of the *Nehemia refrigerating machine* of Metallwerke Neheim Co., Neheim-Ruhr, Germany. This machine uses, for small units, carbon dioxide taken from the evaporator and compressed in the condenser, where it becomes liquid under the influence of pressure and cooling water. The liquid carbon dioxide passes then through a regulating valve back into the evaporator, where it is evaporated and thereby lowers the temperature of the surrounding space. The consumption of CO_2 is slight. A special ventilating arrangement helps to keep the air in the room clear and dry.

*DAS PROBLEM DER TIEFKÜHLUNG, Privatdocent Rud. Plank. *Zeits. für die gesammte Kälte-Industrie*, October, November. 9 pp., 2 diagrams. *h*.

Discussion of materials to be used in *refrigerating machinery for low temperatures* (—76 to —112 deg. fahr.), with data on N_2O. Pressure-volume diagram of N_2O and temperature-entropy diagram are given.

SAFETY APPLIANCES

SCHUTZBRILLEN FUER AUTOGENE SCHWEISZUNG. *Zeits. für Sauerstoff und Stickstoff Industrie*, November 1911. 3 figs. *b*.

Description of *protective appliances* of the firm J. Seipp, Frankfurt a. M., Eschersheim: (*a*) spectacles for autogenous welding, which are held in place by a leather strap without producing any unpleasant pressure on the head, and in which the glasses are fixed, not in a wire frame, but in a rubber band arranged in a way to protect the eyes from sparks and particles of molten metals; (*b*) mask for use in autogenous welding of metals producing poisonous gases, e. g. aluminum, with protective eyeglasses, and a respirator device in which the entering air passes through a special rubber pipe, while the outgoing air has a free passage through a valve which lets the air out but not in; (*c*) a respirator arranged as above but without the protective eyeglasses.

MANIVELLE DE SURETÉ, POUR APPAREILS DE LEVAGE ET MOTEURS À EXPLOSION. *Le Génie Civil*, November 25. 1 p., 7 figs. *Ab*.

Description of three types of *safety starting handles* for elevators and explosion motors which received the prize at the international competition of the French Manufacturers' Association for the prevention of accidents to employees.

STEAM ENGINEERING

SUR LE TIRAGE RATIONNEL DES GÉNÉRATEURS DE VAPEUR, J. Izart. *La Technique moderne*, November. 3 pp., 8 figs. *b*.

Discussion of *natural* (by smokestack) *and artificial* (by blowers) *draft* for steam generators. Natural draft is unsatisfactory, because a brick stack is not economical, is inefficient, and lacks in elasticity in the production of partial vacuum. With a steel stack the friction is less but the economy is still poor. The use of blowers is not a rational method of draft either, because it is as uneconomical as natural draft, and in addition consumes a considerable amount of power. The article is to be continued.

Le chauffage économique des Chaudières, procédé Wilton. *Fer et Acier*, October. 3½ pp., 3 figs. *b.*

Description of the *Wilton process of firing boilers*, claimed to be very economical and efficient.

Ueber die Höhe des Probedruckes von Dampfesseln. *Braunkohle*, November 24. 1 p. *A.*

Article from the *Zeits. der Dampkesseluntersuchung und Versicherungsgesellschaft.* Inspector Fritz Kraus of Vienna discusses the *reasonable hydraulic pressure to which a boiler ought to be subjected during tests for strength.* In 1902 some French engineers tried to show by statistics that the high pressures to which boilers were subjected during hydraulic tests (twice as high as the maximum working pressure) lowered the resisting power of the boilers. Professor von Bach found in 1906 that hydraulic tests are sometimes likely to give doubtful results. The author thinks that a pressure equal to only one and one-half that of the ordinary working pressure ought to be applied in hydraulic tests.

Die weitere Entwicklung der Gleichstromdampfmachine, Boi. *Electrotechnische Zeits.*, November 23. ⅔ p., 2 diagrams. *b.*

Extracts from paper by Professor Stumpf at the meeting of the Society of Marine Engineers (German), on the latest developments in the design of the *straight flow steam engine.* It has been found that, with a carefully designed heating of the cylinder walls, this type of machine can work with saturated steam as economically as with superheated. The designers have also succeeded in reducing from 2 per cent to 4 per cent the clearance in engines having the exhaust into the air or a higher back pressure, this being attained by placing a special valve in the piston.

*Petry-Dereux Grosswasserraum-Wasserrohr-dampfkessel. *Der Practische Maschinen-Konstrukteur*, November 23. 1½ pp., 35 figs. *b.*

Description of the *Petry-Dereux* (Düren, Germany) water-tube boiler with large water space, and its traveling grate, more fully described on a following page.

Calcul de la surface de chauffe des tubes foyers type Fox, Noël Dessard. *Annales des mines de Belgique*, Vol. 6, Pt. 4. 6 pp., 2 figs. *c.*

Analytical method of *calculating the heating surface of Fox flues*, giving a formula which can be applied in practice without the use of a term of compensation for errors.

*L'electricité et la Mécanique à l'Exposition de Charleroi, D. Verden. *Electro, October.* 2½ pp., 3 figs. *b.*

Contains a description of the *Electra low-power turbine* using low-pressure steam from the exhaust of other machines, steam hammers, etc., or simultaneously, low-pressure steam from the exhaust and live steam from a boiler.

*Die Wärmekraftmaschinen auf der Ostdeutschen Ausstellung Posen. 1911, Prof. H. Baer. *Zeit. des Vereines deutscher Ingenieure*, November 25. 12 pp., 44 figs. *B.*

Description of *heat engines and turbines* at the East German Exhibition in Posen, 1911. A fuller description of a 1200-h.p. twin-tandem engine of the Maschinenbau Co., Hirschberg, is given on a following page.

DER EINFLUSZ DES HEISZDAMPFES AUF DIE AUSGESTALTUNG DER DAMPFMASCHINEN, LOKOMOBILEN, LOKOMOTIVEN UND SCHIFFMASCHINEN, H. Lentz. *Zeits. des Oesterr. Ingenieur und Architekten Vereines*, November. 5 pp., 38 figs. *Abc.*

The practice of several German firms, e.g. Lanz in Mannheim, has shown that in a properly designed steam engine the *consumption of heat* falls as the degree of superheat rises. A 300-h.p. stationary steam engine has been constructed with a consumption of heat closely approaching that of a Diesel motor. Similar engines for the propulsion of ships have also been designed.

THERMODYNAMICS

UEBER DIE GRUNDLAGEN DER MECHANISCHEN THEORIE DER WÄRME, F. Hasenöhrl. *Physicalische Zeits.*, November. 4½ pp., 2 curves. *Ac.*

Planck introduced his formula for the *calculation of energy and entropy* of an oscillation instead of the classical formula, $e^{-\frac{\psi}{\theta}} = \int_0^\infty d\, V e^{-\frac{E}{\theta}}$ in order to avoid the so-called equipartition of energy. Planck's formula was, however, intended for a resonator having purely harmonic oscillations, the number of oscillations being independent of the energy. Hasenöhrl shows that if the period of oscillation τ is a function of the energy $\tau\ (E)$; if E has such values that the values of τ do not form a continuous series, and if $\frac{dv}{dE} =$ constant C, then the differences between the successive numbers of oscillations form an arithmetical series (in accordance with the first law of spectra of Deslandres) and, further, such a relation of energy and period of vibrations may be found that the series of possible numbers of oscillations correspond to Balmer's formula ($\tau_m = A \frac{m^2}{m^2-4}$) for the series of spectral lines of hydrogen.

WELDING

NEUE ARBEITSMETHODEN DER AUTOGENEN SCHWEISS UND SCHNEIDVERFAHREN ACETYLEN, No. 20, Theo. Kautny. 1½ pp. *b.*

Description of the *course of instruction* given *in autogenous welding* at the Royal School of Machine Construction in Cologne, Germany. The course lasts three weeks, of which one is devoted to theoretical instruction and two to practical work. Fee, 40M (about $10). The course is open to foreigners and is attended mainly by manufacturers and engineers. There are a well appointed laboratory and shops where the practice of autogenous welding may be studied. Principal attention is paid to welding by acetylene. Article to be continued.

MISCELLANEOUS

PHOTOGRAPHIEREN OHNE CAMERA, Carl von Arnhard. *Zeits. für Electrotechnik und Maschinenbau*, November 23. 1 p., 1 fig. *b.*

Drawings, pictures, tables, etc., *may be reproduced from printed originals* (even from books) by placing a sensitive plate (yellow gelatine appears to be the most suitable) on the side opposite that containing the picture to be photographed, and then exposing the picture to the light of a specially constructed electric lantern for about 12 seconds, the lantern being at a distance of about 15 cm. (6 in.) from the picture. Drawings printed on one side of the paper are reproduced especially well.

*EIN NEUER FLUESSIGKEITSZERSTÄUBER, Gwosdz. *Glückauf*, November 25. $^2/_3$ p., 1 fig. *b.*

Description of a *turbine-driven liquid sprayer* rotating at 12,000 r. p. m.

GUMMI-RIEMEN UND SEILE.. *Gummi-Zeitung*, November 24. 1 p. *a.*

The article claims that *rubber belts and ropes* are better than leather belts and hemp ropes. A rubber belt is said to last longer, to run true even after a long use, and to be less affected by moisture and acid vapors than a leather belt.

RELATIVITETSPRINCIPET, V. Isaachsen. *Electrotecknisk Tidskrift*, November 18. 2 pp. *c.*

A popular exposition of the *principle of relativity*. Article to be continued.

ABSTRACTS OF ARTICLES

Le moteur Da Costa à calotte de distribution rotative. *La Pratique automobile*, November 10.

The Da Costa motor has a valve gear consisting of a rotary valve and a hemispherical cylinder head, both being provided with special segments insuring tightness of fit. In Fig. 1 the working cylinder 1 has a hemispherical cylinder head 2 with openings 3 and 4. The cooling jacket 5 around the cylinder 1 extends (6) into the interior of the wall of the cylinder head 2. On the cylinder head is freely set the rotary valve 7, also hemispherical, with an opening 8, which passes over the openings 3 and 4 during the rotation of the valve. The rotary motion is transmitted to the valve from the engineshaft by the shaft 11 (moving at the same speed as the engineshaft) through a pinion 10 and a gear wheel *g*. On the rotary valve 7 is placed the back cylinder cover 12, provided with passages: 13, leading to the carburetor, and 14, to the muffler. In the upper part of the back cylinder cover is a circular opening corresponding to the openings in the rotary valve and the cylinder head for the spark plug 15, a tight fit being provided by the packing 16 and 17. The function of the valve gear is as follows: The pinion 10 gives to the valve 7 a rotary

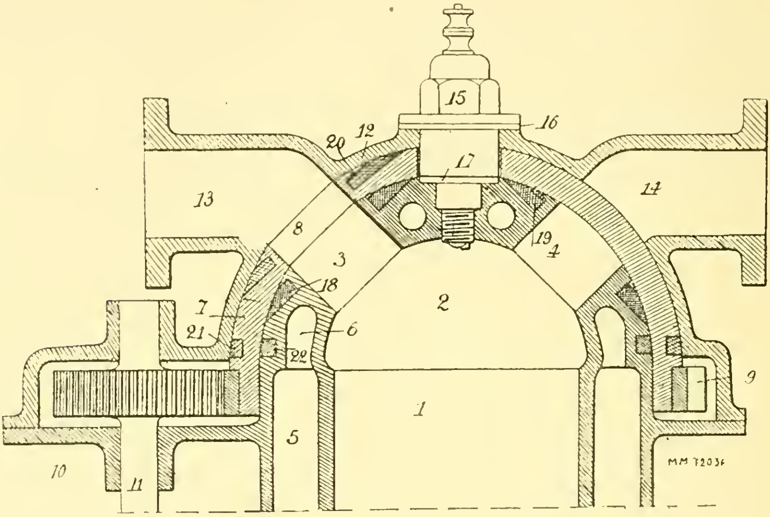
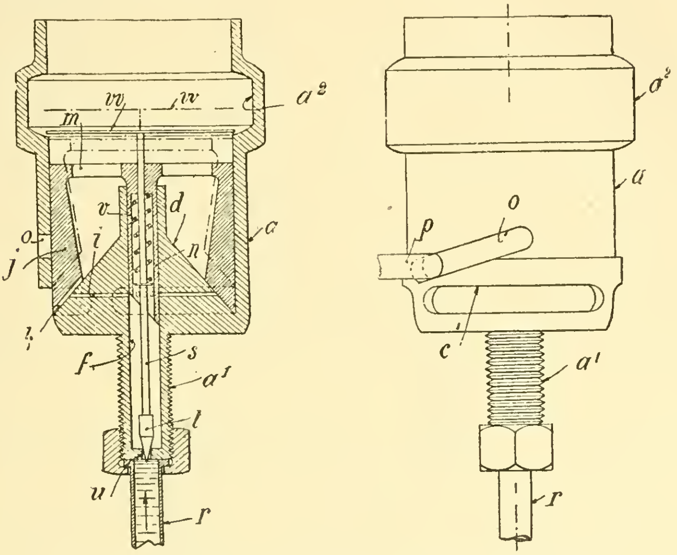


Fig. 1 Da Costa Hemispherical Rotary Slide Valve Motor

motion, which brings the opening 8 either between 3 and 13 (admission) or between 4 and 14 (exhaust). When the opening 8 is in neither of these positions, the combustion chamber is completely closed, as is required for the periods of compression, explosion and expansion. The valve 7 rotates at half the speed of the engineshaft.

Carburateur Supprimant Le Niveau Constant. *La France automobile et aérienne*, November 18.



Figs. 2 and 3 Rebourg Floatless Carburetor

This carburetor has a needle t (Fig. 2) actuated by a spring in a manner such that it closes the passage of the liquid when the carburetor is at rest, and when the carburetor has to begin to act opens it automatically under the influence of the suction of the motor. This allows the carburetor to act in any position whatever, and does away with the float chamber. The carburetor (Figs. 2 and 3) consists of a cylinder a with three side openings c for the admission of air and is connected by the pipe r directly with the fuel, i. e., with no float chamber between. The tank is placed in a way such that the liquid tends to rise in a^1 and in the vertical passage f bored in the conical cap d on the cylinder cover. Into the channel f lead three slots i made in d, radially, in the same plane, from the surface inward. In the channel f moves, with a slight friction, a tubular piston n with an "edge shaped" lower end, the piston ordinarily occupying such a position that only one of the three slots i is open. Inside the piston n moves freely the stem s of the needle t, which ordinarily keeps closed the opening u in the lower extremity of a^1, the needle being kept down by the helical spring v. The stem of the needle has, at its upper end, a disc *w* placed in such a manner that when the needle is down it nearly comes in contact with the walls of the cylinder *a* and so closes it nearly completely. In the cylinder *a* there is a ring-shaped groove a^2, placed so that when the disc *w* is raised by the suction of the motor (as shown by the broken line, and as happens when the needle *t* opens the orifice *u*) there is a free passage around it. The piston *n* is connected by a cross-head *m* with the bush *j*, moving vertically inside the cylinder *a* and having the lower part cut off conically so as to fit exactly *d*. In this lower part a groove *k* is cut in a way such that when *j* is completely down, the external air can pass through this groove into the carburetor. Into the groove *k* leads that of the three slots *i*, which is ordinarily left open by the piston *n*. In the cylinder *a* is cut an inclined slit *o* in which moves a stop-pin with a hand lever at its other end. When the motor is at rest the needle *t* is kept down by its spring and no fuel can pass. As soon as the suction of the motor begins, the disc *w* rises and the needle allows the fuel to come into a^1. If the bush *j* is kept down, the fuel can pass only through the one open slot *i* into the groove *k*, where it is drawn in by the current of air sucked in. That corresponds to the slow working of the motor. For the normal working of the motor, the bush *j* and the piston *n* are raised by the hand lever and passages are opened for the air between *j* and *d* and for the fuel through all the three slots *i*, the arrangements being such that the supply of air is in the right proportion to the supply of fuel.

FORSCHRITTE UND NEUERENGEN AUF DEM GEBIETE DER GASGENERATOREN. (The Gas Producer of the Société Française de Matérial Agricole et Industriel), Gwosdz. *Die Gasmotorentechnik*, November.

The producer shaft has a sheet-iron jacket. From the hopper (Fig. 4) *B* a feeding hopper covered by the valve *D* branches out sidewise. The shaft rests on the ash pan F, closed air-tight and separated from the shaft by the grate *G*. The upper part of the shaft jacket is connected with a pipe *V* going down to the ash pan *F* and having a branch pipe *P* coming axially into the producer shaft. At various heights a number of holes are bored through the shaft walls and its jacket, these holes acting as auxiliary air-ducts. In the pipe *V* leading to the ash pan is situated a fan *Y* for increasing the draft. The pipe *H* connects the ash pan with the water seal *I* of the scrubber *J* in its turn connected with the sawdust-purifier *N*. The installation of several rows of air-ducts at various heights allows the use of the producer for various kinds of fuels. For more compactly laid fuels the lower rows of air-ducts are used. Experience has shown that in this producer a gas poor in tar can be obtained from bituminous fuel.

DIE DEISEL-MASCHINE DER MASCHINENFABRIK J. E. CHRISTOPH A. G., NIESKY, O-L., GERMANY, Ernst Neuberg. *Die Gasmotorentechnik*, November.

What kind of Diesel engine should a factory build, vertical or horizontal? For the supply of stationary plants the horizontal engine has the following advantages: lower cost of production; easier repairs of the piston; absence of galleries and stairs; lesser height of the power house; more convenient arrangement of the exhaust pipes. On the other hand, in building vertical engines the factory can build many units with a small number of patterns, and on account of the small number of patterns, can attain the highest degree of mass production.

The J. E. Christoph Company builds motors of three patterns only: 30 h.p., 65 h.p. and 100 h.p., and from these three patterns the following types are built:

One Cylinder H.P.	Two Cylinders H.P.	Three Cylinders H.P.	Four Cylinders H.P.
30	60	—	—
65	130	200	260
100	200	300	400

By increasing or decreasing the number of revolutions the factory, with these ten types, can fill orders for any machine from 30 to 400 h.p., and what is more important, can produce the cylinders cheaply by making 15 to 25 of each pattern at once. The standardization of the production of all the other machine parts, as far as it is possible, allow their cheaper production, and decreases the amount of parts in stock kept by the agents of the company. The following methods are used to standardize the production of bearings: The middle and outer undivided bearings are made of equal dimensions, and the divided bearings of the spiral gear for the one and two-cylinder motors are made of symmetrical halves, allowing a pattern to be used more than once. In the three and four-cylinder motors one of the braces is made broader to provide for possible heavier stresses. The air-compressor is separate from the main body of the machine, which does away with the connecting rod or crank-driving mechanism, and allows the compressor to be driven by a belt or to be directly

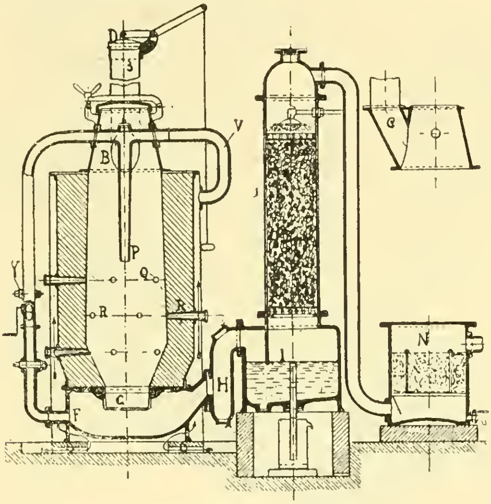


Fig. 4 Gas Producer using Agricultural Waste as Fuel

connected to the shaft, the belt arrangement having the further advantage that the number of revolutions and output of the compressor can be widely varied by a simple change of the belt pulleys, independently of the motor. To avoid excessive clearances the piston heads of the compressor are made concave, and the non-mechanically operated valves are placed at an angle to the axis of the cylinder.

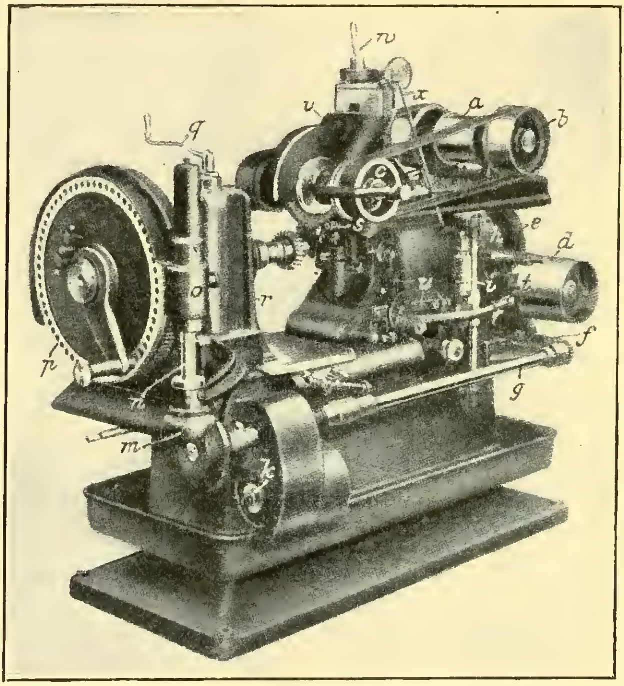


Fig. 5 Automatic Machine for grinding Toothed Wheels

Die selbststätige Zahnräderschleifmaschine von Mayer & Schmidt in Offenbach a. M. Nickel. *Zeits. des Vereines deutscher Ingenieure*, November 25.

The automatic machine for grinding toothed wheels of this type grinds at once the whole surface of a tooth space, and acts like a milling cutter. The grinding wheel, which has the same form as the tooth space to be ground, is set on the front end of a ram-like slide having a reciprocating motion. It is driven by the belt *a* (Fig. 5) and pulleys *b* and *c*, the spindle going at 1700 r. p. m. The reciprocating motion of the slide, making ten double strokes per minute, is transmitted to it from the fixed pulley *d*, which is provided with a belt shifter and is driven from an overhead countershaft.

In this process the grinding disc will change its form after every few strokes, to a certain extent after every single stroke, and such a change might affect the true shape of the teeth ground. The machine has a device (very imperfectly shown in the figure) for keeping the disc in its original shape, consisting of three diamonds which, when placed on a special gage, run along the sides and periphery of the disc. The gage is placed at *s* and is regulated either by hand, by the handle *t*, or automatically by the shaft *i* and rod *u*, in which case the gage is made use of during the operation of the dividing mechanism. If the automatic regulation is used, the same arrangement takes care of the disc after each reciprocating motion of the slide. Since, however, the wear of the grinding disc after a single stroke is really very insignificant, the regulating device is not left in action all the time, but is used only at the end of a full revolution, being locked out the rest of the time by displacing the rod *u*. The number of discs required for this machine is comparatively small, because, for each kind of tooth space, a special gage and not a special disk, is required. The use of the diamonds and gage, which are the important elements of this machine, are not adequately described in the article.

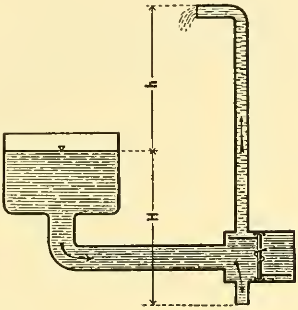


Fig. 6 Hydropulsor

Der Hydropulsor. *Prometheus*, November 11. (Cp. *Zeits. des Vereines deutscher Ingenieure*, February 18, 1911.)

The Hydropulsor (sometimes called Hydropulsator) is a pump based on the principle of Montgolfier's hydraulic ram. The ram, however, could be used only for small amounts of water because the repeated shocks were apt to destroy the poppet valves very rapidly. The Hydropulsor, invented by A. Abraham and constructed by the Ottenser Eisenwerk Company, Altona, Germany, uses a rotary valve instead of poppet valves, thus permitting the apparatus to be built in any size. The arrangements of the parts is shown in Fig. 6. The water under pressure flows downward through the discharge pipe, but when it acquires certain efflux velocity the rotary valve is set in motion by the water, closes the discharge pipe, and at the same time opens the delivery pipe into which the water is driven. The rotating valve then closes the delivery pipe and opens the discharge pipe, thus allowing the mass of water to gain a certain acceleration.

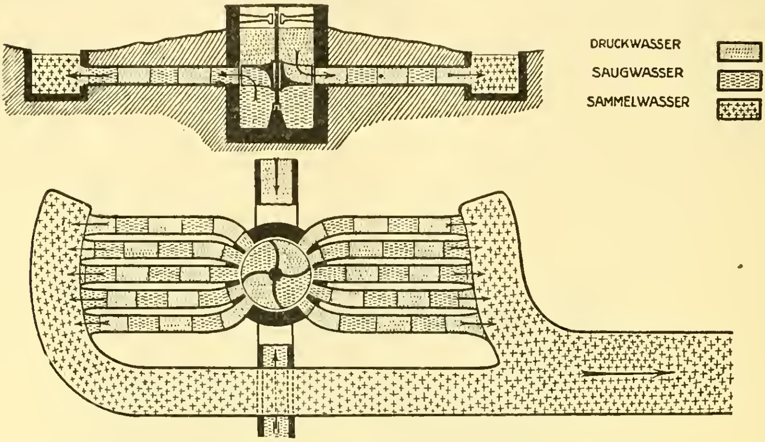


Fig. 7 Hydropulsor in a Well

Druckwasser (water under pressure); Saugwasser (water under suction); Sammelwasser (collector)

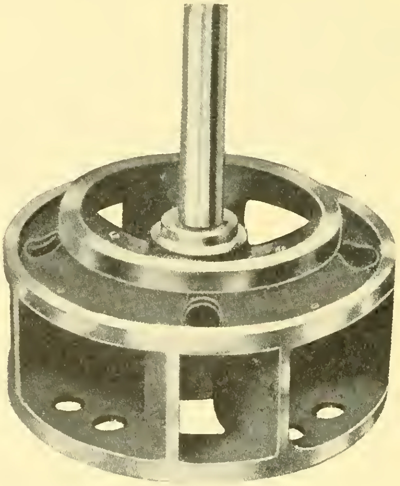


Fig. 8 Hydropulsor Valve

eration. Since it is possible to place several delivery pipes and as many discharge pipes around the valve, large amounts of water can be lifted by a machine of moderate size. The practical arrangement of such a system is shown in Fig. 7. The rotary valve (Fig. 8) is placed in the well on a vertical shaft in such a manner that it divides the well into an upper water space (water under pressure) and a lower (water under suction). The delivery pipes (in Fig. 7, five on each side of the valves) are led to the collectors from the rotary valve. When the water under pressure reaches the upper part of the well space it must then pass into the water pressure chambers of the valve, which open upward, and from them into the delivery pipe. But since the walls of the chambers of the valve are curved like turbine vanes, the passage of water sets the valve into rotation and this results in the delivery pipes being alternately connected, first with the upper part of the water (under pressure) and then with the lower part of the water (under suction). But when a delivery pipe is cut off from the water under pressure by the rotation of the valve, the water in it continues to flow for some time under the action of inertia, and by the time the delivery pipe comes above the lower mass of water, a vacuum is formed in it, into which the water is drawn from below. Before this suction has time to cease and a backward flow begins the rotation of the valve brings the delivery pipe opposite that part of the water under pressure, and the whole cycle .recommences. A hydropulsor has been constructed to use the power of the tides, and is claimed to work satisfactorily.

DAS PROBLEM DER TIEFKUEHLUNG, Rud Planck. *Zeits. für die gesammte Kälte-Industrie,* October, November.

Some mining and chemical industries have lately created a demand for refrigerating machinery giving a temperature of —60 to —80 deg. cent. (—76 to —112 deg. fahr.). NH_3 and SO_2 are inconvenient for such temperatures because they have deep pressure-volume curves; their saturated vapors are, even at a temperature of —76 deg fahr., present in strong vacuum, and it is very difficult to work with such a vacuum for any length of time. CO_2 cannot be used because it solidifies at —56 deg. cent. (—67 deg. fahr.), and experiments of using Pictet's mixture (CO_2 and SO_2) proved to be equally unsuccessful. The cold air engine, as shown lately by the experiments of Lorenz, is uneconomical owing to the large piston surface of the compression cylinder required. The only suitable material seems to be N_2O (laughing gas). The author describes its physical properties and gives its pressure-volume curve, as well as a table of its properties (Table 1).

PETRY-DEREUX GROSZWASSERRAUM-WASSERROHR-DAMPFKESSEL (The Petry-Dereux traveling grate). *Der Praktische Maschinen-Konstrukteur,* November 23.

Chain grates necessitate frequent and expensive repairs owing to their separate parts, bolts, etc., being rapidly destroyed by their exposure to the action of the fire. To avoid this the chains and bolts in the Petry-Dereux traveling grate (Fig. 9) are placed far below the fire line, and therefore not subjected to the direct action of the fire. This grate can be used for such kinds of coal for which the chain grate is not suited, and grate bars can be changed without stopping the work of the boiler.

TABLE 1 PROPERTIES OF N_2O

$R = 19.28$ $\mu = 44$

Temperature			Specific Volume					
$t°$	$T°$ Absolute	Pressure p Atmospheres	Liquid v'	Steam v''	Weight of 1 Cu.M. Steam γ''	Internal Heat of Evaporation ρ	External Heat of Evaporation $AP(v''-v')$	Total Heat of Evaporation r
Cent.	Cent.	Kg. per Sq.Cm.	Cu. M. per Kg.	Cu. M. per Kg.	Kg. per Cu. M.	W. E.	W. E.	W. E.
Fahr.	Fahr.	Lb.per Sq. In.	Cu. Ft. per Lb.	Cu. Ft. per Lb.	Lb.per Cu. Ft.	B.t.u.	B.t.u.	B.t.u.
36.4	309.4	75	0.00255	0.00255	392.0	0	0	0
97.6	524	1065	0.04080	0.04080	24.5	0	0	0
36	309	74.3	0.00218	0.00336	376.0	6.5	0.83	7.3
96.8	523.2	1055	0.03498	0.05376	23.5	25.8	3.28	29.
35	308	72.7	0.00196	0.00334(?)	299.5	11.2	2.35	13.5
95	522.4	1035	0.03136	0.05344(?)	18.7	44.4	9.32	53.6
30	303	65.55	0.00160	0.00452	221.3	23.9	4.5	28.4
86	513.4	930	0.0256	0.07262	13.8	95	17.7	112.5
25	298	58.80	0.00144	0.00560	178.7	31.5	5.7	37.2
77	504.4	832	0.02300	0.08960	11.2	125	22.3	147.5
20	293	52.55	0.00134	0.00673	148.7	37.05	6.65	43.7
68	405.4	745	0.0214	0.1076	9.3	147	26.3	173.
15	288	46.8	0.00126	0.00797	125.5	41.65	7.35	48.0
59	486.4	663	0.02016	0.1276	7.8	165	29.2	194.5
10	283	41.75	0.00120	0.00936	106.9	45.2	8.0	53.2
50	477.4	592	0.01920	0.1496	6.65	179	32.8	211.4
5	278	37.22	0.00115	0.01090	91.8	48.3	8.5	56.8
41	468.4	528	0.01845	0.1744	5.7	192	33.7	225
0	273	33.28	0.00111	0.01261	79.3	50.7	9.0	59.7
32	459.4	471	0.01776	0.2017	4.95	200	35.7	234.9
−5	268	29.73	0.00108	0.01461	68.5	52.8	9.4	62.2
23	450.4	422	0.01728	0.234	4.25	211	37.3	247
−10	263	26.50	0.00105	0.01680	59.5	55.15	9.75	64.9
14	441.4	375	0.01680	0.269	3.7	219	38.7	257.
−15	258	23.53	0.00102	0.01924	52.0	57.3	10.1	67.4
5	432.4	333	0.01632	0.3080	3.25	227	40.1	267
−20	253	20.70	0.00100	0.02170	46.1	59.3	10.3	69.6
−4	423.4	295	0.01600	0.347	2.85	235	40.9	276
−25	248	18.09	0.00098	0.02465	40.6	61.5	10.1	71.6
−13	414.4	257	0.01568	0.395	2.5	244	40.1	284
−30	243	15.70	0.00096	0.02770	36.1	63.6	9.9	73.5
−22	405.4	223	0.01536	0.443	2.25	252	39.6	292
−35	238	13.40	0.00094	0.0320	31.3	65.6	9.8	75.4
−31	396.4	190	0.01504	0.512	1.95	260	38.9	299
−40	233	11.30	0.00093	0.0375	26.7	67.6	9.7	77.3
−40	387.4	160	0.01472	0.600	1.65	268	38.5	306
−45	228	9.55	0.00091	0.0436	22.95	69.5	9.6	79.1
−49	378.4	135	0.01440	0.696	1.4	276	38.1	314
−50	223	7.94	0.00090	0.0517	19.35	71.5	9.5	81.0
−58	369.4	113	0.01408	0.827	1.2	284	37.7	321
−55	218	6.50	0.00088	0.0624	16.04	73.4	9.4	82.8
− 67	360.4	92.3	0.01376	0.999	1.	291	37.3	328
−60	213	5.28	0.00087	0.0759	13.18	75.4	9.3	84.7
−76	351.4	75	0.01344	1.22	0.82	299	36.9	336
−65	208	4.20	0.00085	0.0942	10.62	77.3	9.2	86.5
−85	342.4	59.6	0.01312	1.51	0.66	307	36.5	343.5
−70	203	3.32	0.00084	0.1176	8.51	79.2	9.1	88.3
−94	333.4	47.3	0.01296	1.88	0.53	314	36.1	350
−75	198	2.50	0.00083	0.1550	6.46	81.2	9.0	90.2
−103	324.4	35.5	0.01280	2.48	0.40	322	35.7	358
−80	193	1.90	0.00082	0.2038	4.91	83.1	8.9	92.0
−112	315.4	26.8	0.01264	3.26	0.30	330	35.3	365
−85	188	1.38	0.00081	0.2728	3.67	85.1	8.8	93.9
−121	306.4	19.6	0.01248	4.37	0.23	338	34.9	371.5
−90	183	1.00	0.00080	0.3712	2.70	87.0	8.7	95.7
−130	297.4	14.2	0.01232	5.94	0.165	346	34.5	379.9

Die Wärmekraftmaschinen auf der Ostdeutschen Ausstellung Posen, Maschinenbau A. G., Hirschberg, Germany. *Zeits. des Vereines deutscher Ingenieure*, November 25.

The engine (Figs. 10-14) has the diameter of the high-pressure cylinder 510 mm. (20 in.), the diameter of the low-pressure cylinder 800 mm. (31.5 in.), and stroke 800 mm. (31.5 in.). In the middle is placed a rope-pulley flywheel, 4000 mm. (157.48 in.) in diameter, with grooves for 24 ropes 50 mm. (1.9 in.) thick. The shaft is provided on both ends with overhung cranks working tandem fashion, with the high and low pressure cylinders. Each side of the engine has its own condensation by injection with a 2-cylinder double-stage wet air pump. The engine has the following noteworthy peculiarities of construction: Both the high and low-pressure cylinders are provided with so-called stream-covers; the live steam comes into the cover through a connecting branch in the cylinder, and passes through it into a passage leading to the inlet valve. As a result, the cylinder covers are heated to a high degree, with a view to reducing

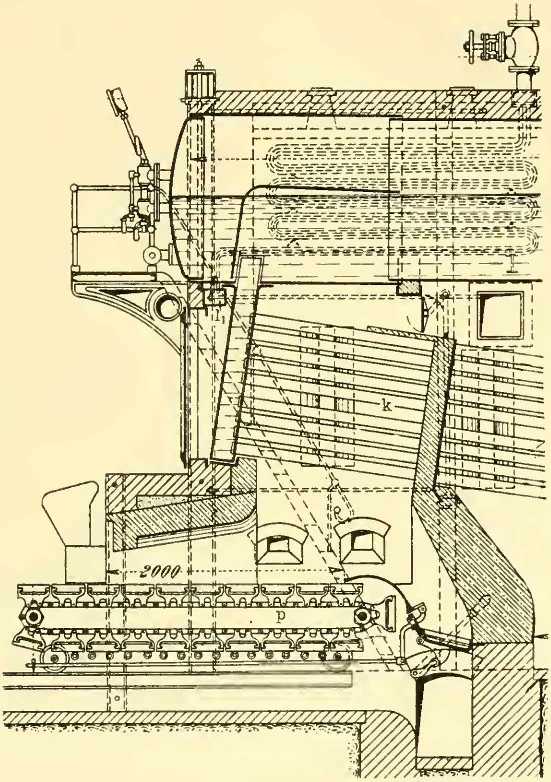


Fig. 9 Petry-Dereux Traveling Grate

the heat losses. The pistons are ground in the cylinder in the lower third of the periphery; this insures a proper guiding of the piston rods without producing any serious pressures in the guiding surface of the pistons. The low-pressure side has, besides the cover heating, also a heating of cylinder walls by receiver steam. In order to avoid heat losses the water of condensation from the walls of the low-pressure cylinder and the receivers is driven by a small pump to the superheaters in the boiler plant. The governor is not placed on top, near the high pressure cylinder, as usually, but down below in the foundation, in a cast-iron casing. With a pressure of 12 atmospheres above atmospheric, and a temperature of 350 deg. cent. (662 deg. fahr.) the engine gives at 130 r.p.m. about 1200 i.h.p., or 1100 effective h.p.

EIN NEUER FLUESSIGKEITSZERSTÄUBER, Gwosdz. *Glückauf*, November 25.

Besides nozzle-sprayers, a new type of sprayers has come into use in which the liquid is atomized by rapidly revolving discs. These sprayers cannot be clogged by dirt like the nozzle sprayers, do not have to be cleaned so often, and can use impure and pit water. In order to attain a high peripheral velocity, and to produce a complete atomizing of the liquid, the firm Gustav Schlick in Dresden, Germany, has lately constructed a turbine-driven atomizer rotating at 12,000 r.p.m. The atomizer (Fig. 14) *a*, which is regularly supplied by water through the pipe *b*, is bolted on to the shaft *c* and is driven by the turbine *d*, placed in the casing *e*. The shaft runs in the two bearings *f* and *g*, of which the bearing *f* is made movable in order that the shaft might automatically adjust itself to the changes of the position of the center of gravity. The steam is conducted to the turbine through the pipe *i*; the exhaust escapes through *k*; *l* is

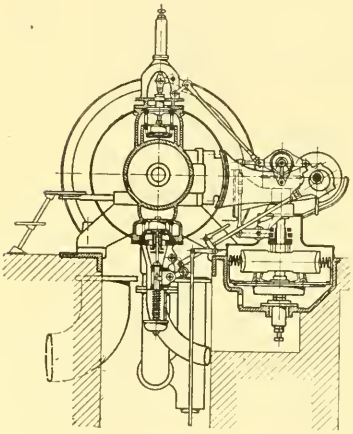


FIG. 10 TWIN-TANDEM ENGINE, HIGH-PRESSURE CYLINDER

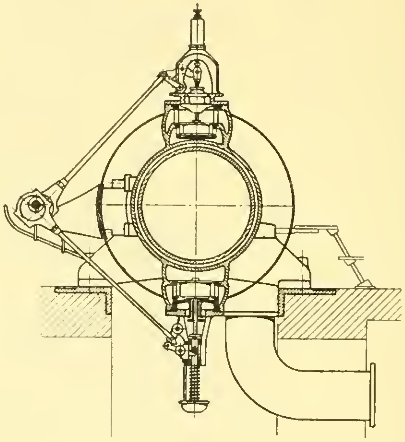


FIG. 11 TWIN-TANDEM ENGINE, LOW-PRESSURE CYLINDER

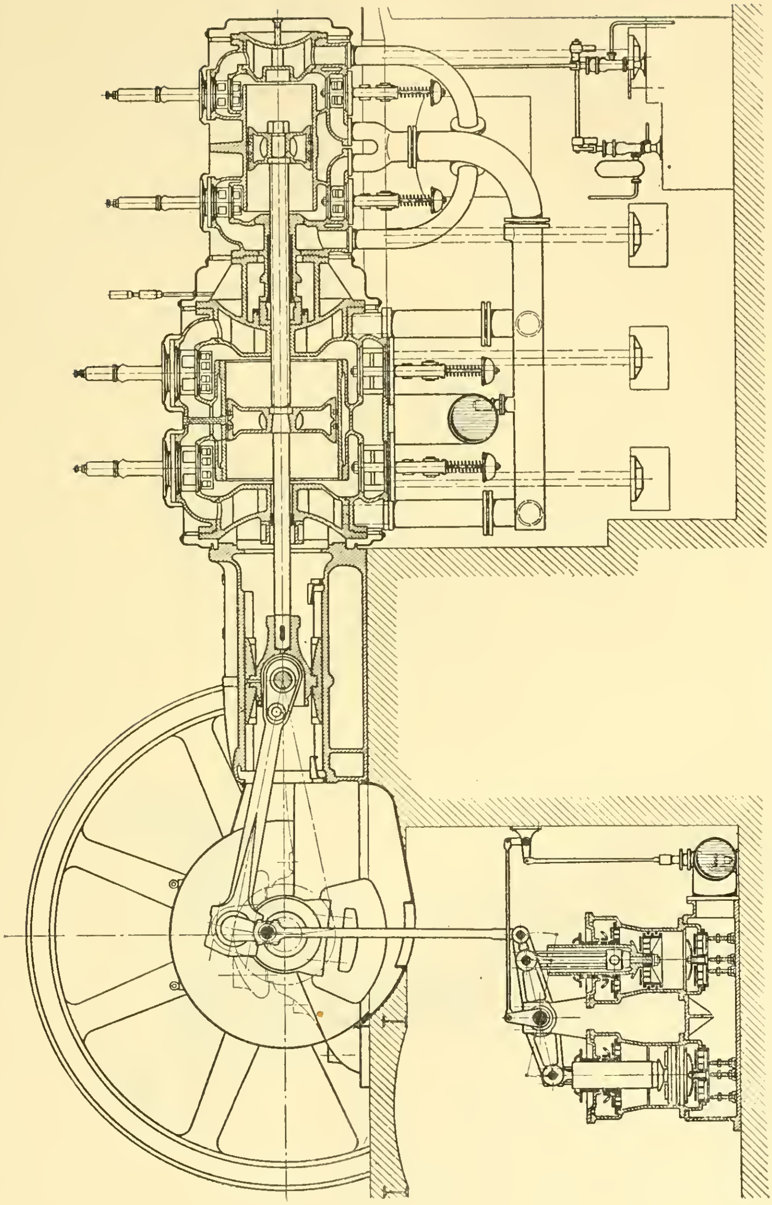


Fig. 12 Twin-Tandem Engine, Longitudinal Section

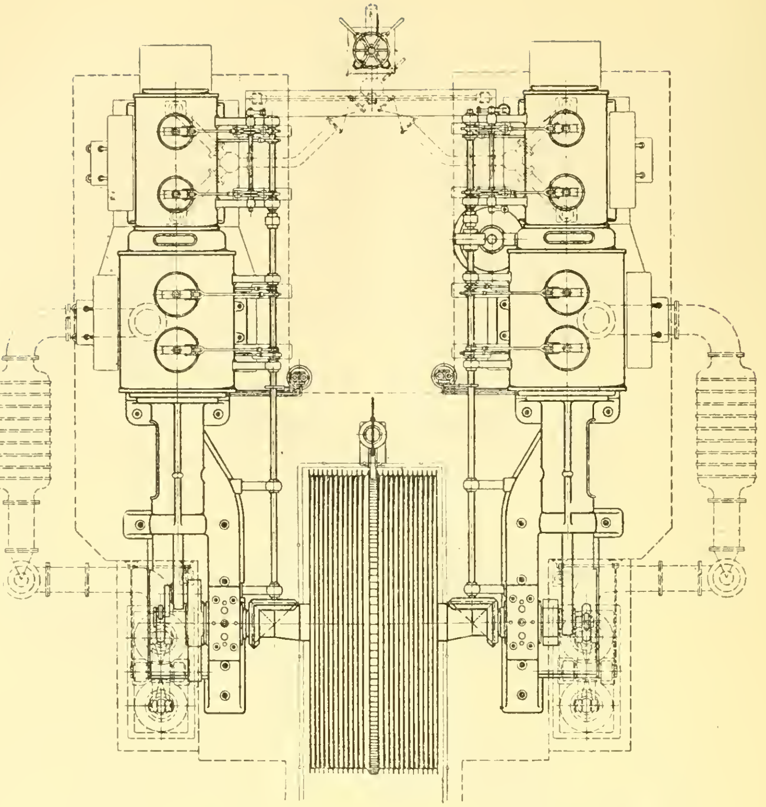


Fig. 13 Twin-Tandem Engine, Plan

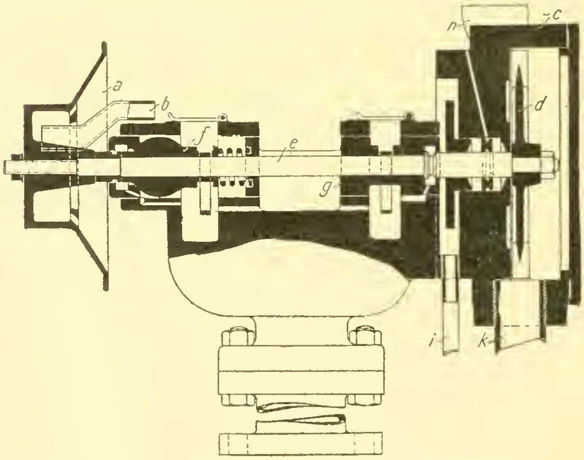


Fig. 14 Turbine-Driven Liquid-Sprayer

a discharge pipe for oil and water of condensation. Compressed air may be used instead of steam. The advantages which are claimed for this type of sprayer are: it can break large amounts of water into finest spray; the amount of water atomized may be regulated by changing the speed of rotation, or the supply of water to the sprayer; the sprayer can be placed in any place and easily set to work, owing to its ability to use compressed air as well as steam.

GENERAL NOTES

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The fourth annual meeting of the American Institute of Chemical Engineers was held at the New Willard Hotel, Washington, D. C., December 20 to 23, 1911 Among the papers were: Advances in Testing Explosives, Clarance Hall; Distribution of Power in Portland Cement Manufacture, R. K. Meade; Problems in the Manufacture of C. P. Acids, J. T. Baker; Combustion of Pulverized Coal, L. S. Hughes; Manufacture of Gelatin, L. Thiele; The Natural Bituminous Rocks of the United States, S. F. Peckham; Symposium on the United States Patent System, E. B. Moore, Edw. T. Fenwick, W. D. Edmonds, R. N. Kenyon; Manufacture and Testing of Carbonic Acid Cylinders, J. C. Minor, Jr.; Some Problems in Chemical Engineering Practice, F. W. Frefichs. The list of excursions was unusually interesting and included a visit to the United States Proving Grounds at Indian Head, Md.; the Patent Office, the Bureau of Standards; the steel plant at Sparrows Point, Baltimore, and the cement plant of the Tidewater Portland Cement Company.

NATIONAL IRRIGATION CONGRESS

The 19th National Irrigation Congress was held in Chicago, Ill., December 5 to 9, 1911. George C. Pardee opened the professional program with an account of the Achievements of the National Irrigation Congress, following which were papers on the Constructive Work of the Reclamation Service, F. H. Newell; Magnitude of Irrigation Interests, R. P. Teele; State Irrigation, W. E. Borah; Government Irrigation in Montana, F. Whiteside; Irrigation by Private Enterprise, R. W. Young; Making the Wilderness Blossom, C. J. Blanchard; Drainage as a Basis for Development, W. L. Park; State Aspect of Drainage, R. V. Fletcher; Reclamation a National Duty, H. C. Leake; One and Indivisible: Forestry, Irrigation, Drainage, Navigation ; the Rivers are the Greatest Assets of the Nation when Regulated for all Beneficial Uses, G. H. Maxwell; The Uses of the Great Lakes, Gardner Williams; Pan American Coöperation in Irrigation and Drainage, John Barrett; Irrigation in Western Asia, A. P. Davis; Irrigation and Prosperity, F. G. Newlands; The Present State of Irrigation Development and a Forecast of the Future, S. Fortier; Irrigation in the Humid States, M. B. Williams; Appropriation and Riparian Rights—The California Doctrine, G. H. Hutton; Drainage to Develop Commerce and Industry, A. R. Lawton; Principles Underlying Water Rights, W. J. McGee; Irrigation Finance, N. E. Webster; Relation between Irrigation and Dry Farming, J. A. Widtsoe; Pumping for Irrigation, T. U. Taylor; The Underground Waters of New Mexico, W. E. Holt; Vital Phases of Reclamation Work, E. J. Watson; The Roosevelt Dam, D. B. Heard; Irrigation from Reservoirs, H. G. Clark; National Aspect of Drainage, M. O. Leighton. Dr. Harvey W. Wiley, Chief of Bureau of Chemistry, Department of Agriculture, was also present and addressed the meeting.

AMERICAN CHEMICAL SOCIETY

The annual meeting of the American Chemical Society was held at Washington, D. C., December 27 to 30, 1911, with headquarters at the New Raleigh Hotel. There were numerous papers on the biological, fertilizer, pharmaceutical and organic phases of chemistry, as well as the following addresses: The Teaching of Physical Chemistry, A. A. Noyes; Physical Chemistry in the Introductory Course, W. D. Bancroft; The Introduction of Physical Chemical Conceptions in the Early Stages of the Teaching of General Chemistry, H. C. Jones; Some Applications of Color Photography in the Teaching of Physical Chemistry, J. H. Mathews; The Resins and Their Chemical Relations to the Terpenes, President Frankforter; Privileges and Responsibilities of the Chemical Analyst, H. P. Talbot; Ostwald's Proposed International Institute of Chemistry, A. L. Voge.

PERSONALS

W. N. Dennison has joined the staff of the Gramophone Co., Ltd., of England, as chief engineer and general superintendent of all their European factories, with headquarters at Hayes, Middlesex, England. Mr. Dennison was formerly connected with the Victor Talking Machine Co., Camden, N. J.

Carl F. Dietz, formerly of the firm of Dietz & Keedy, Boston, Mass., has accepted an appointment as plant engineer of the Norton Co., with headquarters at Worcester, Mass. Mr. Dietz has charge of the engineering and construction department covering the company's various plants in this country and abroad.

E. S. Farwell has opened a consulting engineering office in Kansas City, Mo. He was formerly associated with the Yellow Pine Paper Mill Co., Orange, Tex.

Sidney G. Koon, until recently associated with Jones & Laughlin Steel Co., Pittsburgh, Pa., has joined the staff of Walter B. Snow, publicity engineer of Boston, Mass.

V. M. Palmer, formerly superintendent and chief engineer for the Selden Motor Vehicle Co., Rochester, N. Y., and recently chief engineer and manager of the automobile department for the Shelden Axle Co., Wilkes-Barre, Pa., has resigned this position to go with the B. F. Board Motor Truck Co., Alexandria, Va., as factory manager and chief engineer, in which company he has become financially interested.

R. Sanford Riley, of Providence, R. I., who as president of the American Ship Windlass Co. developed the Taylor Stoker, has organized the Sanford Riley Stoker Co., Ltd., and will manufacture a new self-cleaning underfeed stoker.

Manning E. Rupp has accepted a position as inspecting engineer in the Pittsburgh district with the Isthmian Canal Commission. Mr. Rupp was formerly in the engineering department on the canal work, and of late with Stanley G. Flagg & Co., Philadelphia, Pa., as mechanical engineer.

F. Harvey Searight, formerly chief draftsman on the steam design of power stations for the Southern Pacific Co., has become connected with the San Francisco, Cal., office of the Allis-Chalmers Co.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

AERONAUTICAL SOCIETY. Constitution and By-Laws. *New York.*

———Aeronautical Legislation, T. A. Hill.

———Bulletin. Vanadium Steels—Their Relation to Machine Design, July 27, 1911. *New York, 1911.*

———Meetings of November 12, 19, 26, December 9, 16, 30, 1909.

———What It is and What It does. *1910.* Gift of the society.

ALABAMA POLYTECHNIC INSTITUTE. Catalogue of the Officers and Alumni, 1872–1911. *Opelika.*

———Department of Architecture. Bulletin, vol. 6, no. 4, November, 1911. *Auburn, 1911.* Gift of the institute.

ALCOHOLIC FERMENTATION, Arthur Harden. *New York, Longmans, Green & Co., 1911.*

AMERICAN ASSOCIATION OF DEMURRAGE OFFICERS. Proceedings of the 22d Annual Convention. *Niagara Falls, 1911.* Gift of Demurrage Commissioner.

AMERICAN PRACTICE IN CLEANING BLAST FURNACE GAS, Samuel K. Varnes. Journal, Engineers' Society of Pennsylvania, August 1911. *Harrisburg, 1911.* Gift of the author.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Transactions, vol. 32, 1910. *New York, 1911.*

AUTOGENOUS WELDING (Epurite Process). Practical Application of the Oxy-Acetylene Blow Pipe, F. C. Cutler. *New York, 1907.* Reprinted from Cassier's Magazine, September 1907. Gift of Worcester Pressed Steel Company.

AUTOMOBILE TRADE DIRECTORY, October 1911. *New York, 1911.* Gift of Automobile Trade Directory Company.

CHEMISTRY OF THE COAL-TAR DYES, I. W. Fay. *New York, D. Van Nostrand Co., 1911.*

CHICAGO, SANITARY DISTRICT. Report on Sewage Disposal, G. M. Wisner, October 12, 1911. *Chicago, 1911.* Gift of the author.

CONGRESO CIENTIFICO (1° PAN AMERICANO). Ciencias Naturales Antropologicas y Etnologicas, vol. 1. *Santiago de Chile, 1911.*

COST KEEPING FOR MANUFACTURING PLANTS, S. H. Bunnell. *New York, D. Appleton & Co., 1911.* Gift of the author.

A general discussion of the subject, with reproductions of blanks and forms used for various purposes. The chapter on Cost of Labor reviews the various plans suggested by Halsey, Taylor, Gantt and others for rewarding extra efficient workmen. The treatment of the subject throughout is philosophical. The work is certainly one of timely interest.

ELECTRIC CRANE CONSTRUCTION, C. W. Hill. *London, 1911.*

DIE ELEKTRIZITÄT IM HAUSE, George Dettmar. Gift of the author.

ENGINEERS' AND MECHANICS' POCKET-BOOK, Chas. H. Haswell. ed. 7. *New York, 1851.* Gift of R. B. Bullock.

DROP FORGING, DIE SINKING AND MACHINE FORMING OF STEEL, J. V. Woodworth. *New York, N. W. Henley Pub. Co., 1911.*

EXPERIMENTS ON THE SEGREGATION OF STEEL INGOTS IN ITS RELATION TO PLATE SPECIFICATIONS, C. L. Huston. Reprinted from American Society for Testing Materials, Proceedings, vol. 6, 1906.

EXPLANATION OF THE WORKS OF THE TUNNEL UNDER THE THAMES FROM ROTHERHITHE TO WAPPING. *London, 1842.* Gift of R. R. Lister.

FACTORY ACCOUNTS, THEIR PRINCIPLES AND PRACTICE, E. Garcke and J. M. Fells. ed. 6. *London, 1911.*

FRAMED STRUCTURES AND GIRDERS, THEORY AND PRACTICE, E. Marburg. Vol. 1, Stresses. *New York, McGraw-Hill Book Co., 1911.*

FUTILITY OF TECHNICAL SCHOOLS IN CONNECTION WITH MECHANICS AND MANUFACTURING OR ELECTRICAL AND CIVIL ENGINEERING, R. T. Crane. *Chicago, 1911.* Gift of the author.

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MUSEUM COÖPERATION IN THE HUDSON-FULTON CELEBRATION, 1909, G. F. Kunz. Reprinted from Proceedings of American Association of Museums, vol. 4, 1910. Gift of the author.

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OIL ANALYSIS, SHORT HAND-BOOK, A. H. Gill. ed. 6. *Philadelphia, J. B. Lippincott Co., 1911.*

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PITTSBURGH BUREAU OF WATER. Annual Report of the Superintendent, 1910. *Pittsburgh, 1911.* Gift of the bureau.

POOR'S MANUAL OF INDUSTRIALS, 1911. *New York, 1911.*

PRACTICAL THERMODYNAMICS, F. E. Cardullo. *New York, McGraw-Hill Book Co., 1911.*

PRINCIPLES AND METHODS OF GEOMETRICAL OPTICS ESPECIALLY AS APPLIED TO THE THEORY OF OPTICAL INSTRUMENTS, J. P. C. Southall. *New York, Macmillan Co., 1910.*

PRODUCTION FACTORS IN COST ACCOUNTING AND WORKS MANAGEMENT, A. H. Church. *New York, 1910.*

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SOLUBILITIES OF INORGANIC AND ORGANIC SUBSTANCES, Atherton Seidell. *New York, D. Van Nostrand Co., 1911.*

STEAM TURBINE DESIGN WITH ESPECIAL REFERENCE TO THE REACTION TYPE, John Morrow. *New York, 1911.*

STRUCTURAL ENGINEERING, Joseph Husband and William Harby. *New York, Longmans, Green & Co., 1911.*

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TREATISE ON HYDRAULICS, H. J. Hughes and A. T. Safford. *New York, Macmillan Co., 1911.*

A textbook on certain parts of the broad subject of hydraulics, viz., water pressure, stability o simple structures subjected to water and its measurement and the principles of hydraulic motors. The design of motors, hydraulic machinery and power plants is omitted. The treatment of the flow from nozzles through fire hoze is particularly clear.

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DIAMOND CHAIN & MFG. CO., *Indianapolis, Ind.* Power chains and sprockets, 96 pp.

EXCELSIOR DRILL & MFG. CO., *Denver, Colo.* Excelsior airometer, 6 pp.

FAWCUS MACHINE CO., *Pittsburgh, Pa.* Worm gearing, 8 pp.

GESELLSCHAFT FÜR HOCHDRUCK-ROHRLEITUNGEN, *Berlin.* Power and water mains, 108 pp.

HESS-BRIGHT MFG. CO., *Philadelphia, Pa.* Heavy truck wheel hubs and various designs of bearings, 9 pp.

INGERSOLL-RAND CO., *New York, N. Y.* Rock drill, 16 pp.

LEHIGH CAR, WHEEL AND AXLE WORKS, *Fullerton, Pa.* Fuller-Lehigh pulverizer mill, 44 pp.

MCNABB AND HAVLIN MFG. CO., *New York, N. Y.* Catalogue of brass and iron fittings for steam, water and gas, 1911, 371 pp.

STERLING MACHINE CO., *Norwich, Conn.* Mechanical lubricator for general internal lubrication, 8 pp.

VALLEY CITY MACHINE WORKS, *Grand Rapids, Mich.* Wood-working machinery, 16 pp.

WESTINGHOUSE, CHURCH, KERR & CO., *New York, N. Y.* Central power stations, 49 pp.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for the Bulletin must be in hand before the 12th of the month. The list of men available is made up of members of the Society, and these are on file in the Society office, together with names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

0133 Works manager wanted. Old established and well organized company employing 1000 men, manufacturing high-class product, wishes to secure capable works manager of large experience in production of small and accurate mechanisms, such as adding machines, typewriters, firearms, etc. Man under 40 years of age preferred. Applicants are requested to give experience in full; state age, positions occupied, and furnish list of references. To right man, permanent position is assured at liberal salary. Location New York State. Address, care of Am. Soc. M. E.

0134 General manager to take charge, under the president, of production and sales. Foundry employing 500 men, making pipe and fittings, heating boilers and steam fittings, also manufacture of radiators. Location Montreal. Necessary that applicant should have wide experience, both commercial and technical, in manufacture and sale of heating appliances.

0135 Wanted engineer who is familiar with designing hydraulic machinery, especially centrifugal pump. Location Middle West.

0136 Man of all-around engineering knowledge, good organizer and tactful, as head of department of large Ohio concern. Address, care of Am. Soc. M. E.

0137 Wanted by large Eastern manufacturer, designer to handle line of high-grade gate valves up to largest size. State experience, salary expected, etc. Address letters for this position care of the Society.

0138 Expert designer of cameras, preferably one with large experience with film cameras and familiar with patents on same, for firm in Middle West. Salary commensurate with ability to meet the requirements for this position.

0139 Sales engineer with experience in the application of refractory materials for the gas and metallurgical industries, also other branches where refractory fire clay materials are used, principally power plants, sugar refineries, etc. State experience and references. Location New York.

MEN AVAILABLE

332 Teacher of mechanical engineering, at salary of not less than $3000, where there are opportunities for advancement and consulting work; or position

in commercial life as designing engineer, superintendent or works manager with firm manufacturing any variety of heavy machinery, steam or gas engines or machine tools preferred.

333 Member, desires to represent New York firm in Boston and New England states. Already established. Sales engineer for any line of machinery on commission basis. Extensive experience.

334 Junior, experienced in special tool design and in charge of men; shop, pipe, plumbing and sheet metal work, steel foundry, power plant design and construction; would like position promising advancement.

335 Engineer of proven executive ability, wide experience in manufacturing heavy and light machinery, including iron and brass foundry practice; desires to become connected with or represent machinery manufacturer. At present officer of company manufacturing heavy machinery.

336 Engineer of varied experience, at present employed, desires change. Prefers design, construction and operation of cement mills; would consider general engineering. Thorough, reliable, systematic, and good organizer. Salary $2500.

337 Junior, age 28, college training, five years' experience as shop foreman, sales engineer, and contractor. At present with large locomotive works; desires position as purchasing agent or in purchasing department.

338 Mechanical-electrical engineer, 11 years' broad experience, government, railroad and factory connections. Competent as contractors' or engineer's assistant and as industrial inspector and plant engineer.

339 Junior, age 28, technical graduate, seven years' experience with contractors and engineers as draftsman, estimator, assistant to engineer in charge, selling, heating and ventilating, design of railroad cars and contractors' equipment; would like to make change first of year for commercial position calling for engineering experience. At present engaged with contracting company.

340 Graduate mechanical engineer, experienced in design and sale of heating, ventilating and drying apparatus. Specialist in mechanical draft and general boiler room practice. Six years in present position as sales engineer with manufacturer of above apparatus.

341 Member with wide experience as superintendent, modern machine shop practice, expert on tools and methods for increasing production and reducing costs.

342 Student member; Cornell graduate, practical experience with water-tube boiler company; will consider any proposition where there is good opportunity for advancement.

343 Junior, 30 years of age, 12 years' experience designing and building automatic machinery, variable speed devices and foundry equipment, desires position as plant engineer or assistant superintendent. Experienced in handling large production of duplicate parts in foundry and shop. At present employed in similar capacity.

344 Graduate mechanical engineer, nine years' experience; in responsible charge of six power plants, desires position in power plant or manufacturing work in the vicinity of New York.

345 Junior, at present employed as draftsman and designer by hydro-electric company, would like to make connection as testing engineer in large manufacturing plant or as manager or assistant manager of power plant. Technical education and training.

346 Experienced designer of special machinery, tools and fixtures for manufacturing purposes; expert in manufacturing equipment; desires responsible position in the Middle West.

347 Young mechanical engineer, Cornell graduate, desires position as assistant to manager with a view to working into sales or engineering department. Location immaterial.

348 Mechanical engineer desires position as manager or superintendent of small growing factory; 32 years of age; married; technical graduate. Four years' practical experience in machine shop and drafting room; four years devising and installing complete cost, shop and production systems; three years as factory executive in responsible charge. Experienced in laying out and installing industrial plants and electric installations.

349 Mechanical and electrical engineer, Cornell graduate, ten years' experience, in steam and hydraulic power-plant construction, gas work, building construction, including reinforced concrete, factory superintendence and maintenance, desires position with consulting or contracting firm or as executive engineer in manufacturing concern.

CHANGES IN MEMBERSHIP

CHANGES IN ADDRESS

ANGSTRÖM, Carl (1883), Cons. Engr., Skeppargatan 5, Stockholm, Sweden.

ANGUS, Robert (1891), Cons. Engr., 705 Confederation Life Bldg., Toronto, and 514 William St., London, Ont., Canada.

BAILEY, Frederic W. (Junior, 1901), 527 Linwood Ave., Buffalo, and Skaneateles, N. Y.

BANKS, Thomas Dent (Junior, 1910), Asst. Engr., Dept. Pub. Service, and *for mail*, 163 W. 9th Ave., Columbus, O.

BARSTOW, Francis Loring (1905; 1911), Engr., Leitch & Barstow, Engrs., 172 Main St., and 691 State St., Springfield, Mass.

BENTON, George H. (1908), Pres. and Mgr., Benton Valve Co., 140 Liberty St., New York, N. Y., and *for mail*, Metuchen, N. J.

BERRY, Edgar H. (1905; 1907), Hotel Euclid, Cleveland, O.

BRADY, Joseph Benjamin (Junior, 1910), Joseph T. Ryerson & Sons, 16th and Rockwell Sts., and 1806 S. Homan Ave., Chicago, Ill.

CARLSSON, Carl A. V. (1905), Mech. Engr., 3921 Eighth St., N. W., Washington D. C.

CARPENTER, Alfonso H. (Associate, 1895), V. P., Acme Mchy. Co., Cleveland, O., and *for mail*, Westlake Hotel, Los Angeles, Cal.

CATLIN, William Lyle (Junior, 1906), Supt., The Wheland Co., and 608 Kirby Ave., Chattanooga, Tenn.

COWGILL, Paul Everett (Junior, 1910), The Weinman Pump Mfg. Co., and 1775 Franklin Park, S., Columbus, O.

DENNISON, Wilburn Norris (1905), Ch. Engr. and Genl. Supt., The Gramophone Co., Ltd., English and Continental Wks., Hayes, Middlesex, England.

DIETZ, Carl F. (1903; 1910), Plant's Engr., Norton Co., Worcester, and *for mail*, 214 Lynn Fells Parkway, Melrose, Mass.

DUNKIN, William Van (1909), Instr. Mch. Design, Univ. of Ill., and *for mail*, University Sta., Urbana, Ill.

FALKENAU, Arthur (1886), Industrial and Cons. Engr., 165 Broadway, and *for mail*, 911 Park Ave., New York, N. Y.

FRANKS, Fredk. B. (1904), Mgr. Operating and Constr. Cement Plant, Bath Portland Cement Co., Bath, Pa.

GRIFFITHS, Leonard L. (1905; 1908), Pres. and Mgr., The L. L. Griffiths Engrg. Co., Cons. Civ. Mech. and Elec. Engrg., 708 Trust Bldg., Dallas, Tex.

HEAD, Francis (1906), Engr. of Constr., The Sao Paulo Tramway, Light & Power Co., Ltd. Sao Paulo, Brazil, S. A.

HOPPES, John J. (1890), Pres., Hoppes Mfg. Co., and Trump Mfg. Co., and *for mail*, 1330 E. High St., Springfield, O.

HUSSEY, Charles Ward (Junior, 1908), Asst. Engr. Mechanigraph Dept., Topping Bros., 122 Chambers St., New York, and *for mail*, 33 St. Andrews Pl., Yonkers, N. Y.

JACKSON, Charles J. (1905), Secy. and Genl. Mgr., Easton Tool & Mch. Co., 39 N. Sitgreaves St., Easton, Pa.

LOGAN, John W. (1894; 1899; 1904), Mgr. Steel Wks. Dept., Alan Wood Iron & Steel Co., Conshohocken, Pa.

McDEWELL, Horatio S. (Junior, 1908), Gas Eng. Erecting Engr., Allis-Chalmers Co., Milwaukee, Wis., and *for mail*, The Adamston, 251 W. 89th St., New York, N. Y.

MacGILL, Charles Frederick (1896), Twin City Lines, 406 N. Snelling Ave., and *for mail*, 1489 W. Minnehaha St., St. Paul, Minn.

MERRILL, Albert S. (Junior, 1903), 334 Bushkill St., Easton, Pa.

MILLER, John S. (1900; 1907), Natomas Consltd. of Cal., Natoma, Cal.

MOORE, Harold T. (Associate, 1907), Cruse-Kemper Co., Ambler, and *for mail*, 2031 Spruce St., Philadelphia, Pa.

MUHLFELD John E. (1908), V. P. and Genl. Mgr., Kansas City So. Ry., and *for mail*, 3712 Washington St., Kansas City, Mo.

RICHTER, Ernst (1890), Ch. Draftsman, The G. A. Gray Co., Cincinnati, and *for mail*, Lafayette Circle, Clifton, Cincinnati, O.

RYAN, Harris J. (1896), Prof. Elec. Engrg., Leland Stanford Jr. Univ., Stanford Univ. P. O., and *for mail*, La Jolla, Cal.

SALMON, Frederick W. (1900; 1904), Civ. and Mech. Engr., Murray Iron Wks., Burlington, Ia., and *for mail*, Owen Sound, Ont., Canada.

SAWFORD, Frank (1909), Canadian Collieries, Ltd., Victoria, B. C., Canada.

SCHAUM, Otto W. (1894), Mfr. of Textile Mchy., Glenwood Ave. and 2d St., and *for mail*, 1508 Allegheny Ave., Philadelphia, Pa.

SMART, Richard Addison (1894; 1900; 1906), Canadian Home Land Co., Ltd., Bank of Hamilton Chambers, Hamilton, Ont., Canada.

TIFFT, Robert Hull (Junor, 1910), Westinghouse, Church Kerr & Co., 10 Bridge St, New York, N. Y.

NEW MEMBERS

ALLEN, John L. (1911), V. P. and Genl. Mgr., Hastings Motor Shaft Co., Hastings, Mich.

BACHMAN, Robert A. (1911), Mgr., Edison Storage Battery Co., Orange, and *for mail*, West Orange, N. J.

BARR William Henry (Associate, 1911), Genl. Mgr., Lumen Bearing Co., and 1155 Sycamore St, Buffalo, N. Y.

BATT, William Lorraine (Junior, 1911), Ry. Engr., The Hess-Bright Mfg. Co., 21st and Fairmount Ave., Philadelphia, Pa.

BECK, Charles Edgar (Junior, 1911), Sales Engr., De La Vergne Mch. Co., 1504 Fisher Bldg., and *for mail*, 4855 Winthrop Ave., Chicago, Ill.

BRAKEMAN, Roy Edgar (1911), Asst. Ch. Engr. Steel Wks. and Blast Furnace Dept., Tenn. Coal, Iron & R. R. C., and *for mail*, Box 36, South Highland, Sta., Birmingham, Ala.

BRENNAN, James (Junior, 1911), Ch. Engr., Crucible Steel Co. of Am., 2014 Oliver Bldg., and *for mail*, Beechwood Blvd , E. D., Pittsburgh, Pa.

BURLEIGH, William Henry (Junior, 1911), 1418 Arlington Ave., Davenport, Ia.

BURNS, Homer S. (1911), Field Supt., Westinghouse Church Kerr & Co., and *for mail*, Box 248, Sta. B. Hamilton, Ont., Canada.

CAIRNS, William (1911), Genl. Mgr., The Parish & Bingham Co., and *for mail*, 1421 E. 85th St., Cleveland, O.

CARTER, Edgar Robert, Jr. (Junior, 1911), Mech. Engr., Evans, Almirall & Co., 316 Confederation Life Bldg., Toronto, Canada, and Tompkinsville, N. Y.

CASSIDY, Andrew George (1911), M. M,. Waltham Watch Co., Waltham, Mass.

CHALMERS, John Brown (Junior, 1911), Instr., Pratt Inst., and *for mail*, 244 DeKalb Ave., Brooklyn, N. Y.

COOK, Thomas R. (1911), Asst. Engr. M. P., Office Genl. Supt. M. P., Pa. Lines West, and *for mail*, 205 N. Negley Ave., Pittsburgh, Pa.

COOK, William Pierson, Jr. (Junior, 1911), Engr., The Griscom-Spencer Co., 90 West St., New York, and *for mail*, 1111 Dean St., Brooklyn, N. Y.

CRAIGLOW, Harry H. (Junior, 1911), Plant Engr., The Buckeye Steel Castings Co., and *for mail*, 80 Wood Ave., Columbus, O.

CROCKER, Arthur George (Junior, 1911), Leading Draftsman, Chicago & Northwestern Ry., and *for mail*, 344 N. Howard Ave., Chicago, Ill.

DENT, John Adlum (Junior, 1911), Instr. Mech. Engrg., Univ. of Ill., Urbana, Ill.

DOW, Benjamin Warren (Junior, 1911), Asst. Engr. Constr. Wk., Stone & Webster Engrg. Corp., 147 Milk St., Boston, and *for mail*, 7 Standish St., Dorchester, Mass.

DOW, Charles Eugene Willey (1911), Selling Agt. and Mech. Engr., Am. Moistening Co., Boston, and *for mail*, 7 Standish St., Dorchester, Mass.

DOWD, Wyllys E., Jr. (1911), Philadelphia Mgr., Power Spec. Co., Land Title Bldg., Philadelphia, Pa., and University Club, New York, N. Y.

DUNLAP, George W. (1911), Supt. Power Stations, Worcester Consltd. St. Ry. Co., and *for mail*, 107 Main St., Worcester, Mass.

DUSOSSOIT, Octave (Associate, 1911), Res. Agt., Hohmann & Maurer Mfg. Co., Boston, and *for mail*, 156 Mason Terrace, Brookline, Mass.

EDWARDS, William B. (1911), Cons. Engr., The United Shoe Machy. Co., and *for mail*, 17 E. 9th St., Derby, Conn.

ERWIN, William W. (1910), N. Y. Edison Co., 55 Duane St., New York, N. Y.

FOGARTY, William James (1911), Mech. Engr., Barney & Smith Car Co., and *for mail*, 74 Fountain Ave., Dayton, O.

FULTON, Arthur Oram (Junior, 1911), Sales Engr., Wheelock, Lovejoy & Co., Boston, and *for mail*, 21 Harrington St., Newtonville, Mass.

GOLDSMITH, Clarence (1911), Asst. Engr. in Charge High Pressure Fire Service, Pub. Wks. Dept., City of Boston, 1 City Sq., Charleston, Mass.

GUNN, Charles M. (1911), Pres. and Mgr., Columbia Steel Co., 503 Market St., San Francisco, Cal.

HARDING, James Morgan (Junior, 1911), Sales Engr., Dodge Mfg. Co., 815 Arch St., Philadelphia, Pa.

HARRIS, Harry E. (1911), 24 Orchard St., Greenfield, Mass.

HINRICHS, Frederic William, Jr. (1911), Asst. Prof. Applied Mech., Univ. of Rochester, and *for mail*, 216 Oxford St., Rochester ,N. Y.

HOFFMANN, Simon (1911), First V. P., Loco. Superheater Co., 30 Church St., New York, N. Y.

HUNTER, Charles Welsh (Junior, 1911), Gas Engr., Stone & Webster Engrg. Corp., 147 Milk St., Boston, Mass.

JACKSON, Charles Arthur (1911), Mech. and Hyd. Engr., The Pelton Water Wheel Co., 90 West St., New York, N. Y.

KAUFFMANN, Frederick F. (1911), Asst. to Ch. Engr., N. Y. Shipbuilding Co., and *for mail*, 909 Pine St., Camden, N. J.

KING, Charles Arthur (Junior, 1911), Asst. Cons. Engr. to Henry C. Meyer, Jr., 1 Madison Ave., New York, N. Y., and *for mail*, 911 Watchung Ave., Plainfield, N. J.

KONSTANKEWICZ, Michael John (Junior, 1911), Asst. Mech. Engr., The Strathmore Paper Co., Mittineague, Mass.

KOPLIN, Robert Deemer (Junior, 1911), Y. M. C. A. Bldg., Wilkes-Barre, Pa.

KORNFELD, Alfred Ephraim (Associate, 1911), Mgr., Engineering News Publishing Co., 505 Pearl St., New York, N. Y.

LAUGHLIN, Alex, Jr. (Junior, 1911), Engr., Alex. Laughlin & Co., Lewis Bldg., Pittsburgh, Pa.

LESSER, W. H. (Junior, 1911), Mech. Engr., Philadelphia & Reading Coal & Iron Co., and *for mail*, 604 N. 3d St., Pottsville, Pa.

LINDSTROM, J. A. (1911), Struc. Engr., Genl. Chem. Co., 25 Broad St., New York, and *for mail*, 97A Seventh Ave., Brooklyn, N. Y.

MARTIN, George W. (1911), V. P. and Genl. Mgr., The N. Y. Service Co., 320 Broadway, New York, N. Y.

McMURTRY, Alden Lothrop (1911), 1737 Broadway, New York, N. Y.

MERRILL, Joseph J. (1911), Ch. Engr., Corn Products Refining Co., 29 E. Madison St., and *for mail*, 229 S. Central Park Ave., Chicago, Ill.

MURPHY, William T. (Junior, 1911), Mgr., Stand. Mchy. Co., 7 Beverly St., Providence, R. I.

NESBIT, Joseph Newton Gray (1911), Prof. Exper. Engr., Ga. Sch. of Tech. Atlanta, Ga.

OHLSON, Olof (1911), Mech. Supt., Waltham Watch Co., Waltham, and *for mail*, 472 Crafts St., West Newton, Mass.

PEARSON, Albert L. (1911), Elec. Engr., Lockwood, Greene & Co., 93 Federal St., Boston, Mass.

PETERSON, John William (1911), Pres. and Mgr., Peterson Engrg. Co., 50 Church St., New York, N. Y.

PIERPONT, Robert (1911), Factory Mgr. and Engr., Olds Motor Wks., and *for mail*, 222 Genesee St., Lansing, Mich.

PUGSLEY, Edwin (Junior, 1911), Spec. Apprentice, Winchester Repeating Arms Co., and *for mail*, 110 Whitney Ave., New Haven, Conn.

QUICK, Ray Lewis (Junior, 1911), Pratt & Whitney Co., and *for mail*, 12 Babcock St., Hartford, Conn.

QUIRKE, Edward D. (1911), Designer and Checker, Natl. Tube Co., and *for mail*, 119 W. South St., Kewanee, Ill.

RANDALL, John Arthur (Junior, 1911), Instr. Mech. and Heat, Pratt Inst., Brooklyn, N. Y.

REGAN, Joseph Charles (1911), Supt., Yale & Towne Mfg. Co., and 370 Summer St., Stamford, Conn.

RICHARDSON, Charles Germane (1911), Sales Engr. Meter Dept., Builders Iron Fdy., and *for mail*, 65 Comstock Ave., Providence, R. I.

ROWNTREE, Bernard (Associate, 1911), East. Engr., Burdett-Rowntree Mfg. Co., Rm. 1883, 50 Church St., New York, N. Y.

SACHS, Joseph (1911), V. P. and Genl. Mgr., The Sachs Laboratories, Inc., 103-105 Allyn St., Hartford, Conn.

SAEGMULLER, George Nicholas (1911), Mech. Engr., Mfr., Bausch & Lomb Optical Co., and *for mail*, 1100 St. Paul St., Rochester, N. Y.

SAYRE, William Heysham (1911), Pres., Am. Abrasive Metals Co., Mgr., Internatl. Contr. Co., 50 Church St., New York, N. Y.

SCHAEFER, Frederick Rullman (Junior, 1911), Sales Engr., Taylor Iron & Steel Co., 100 Broadway, New York, N. Y.

SCHALLER, Alwin Louis (Junior, 1911), Ch. Draftsman, McEwen Bros., and *for mail*, 30 Jefferson St., Wellsville, N. Y.

SMITH, William (1911), M. M. Eliza Furnaces, Jones & Laughlin Steel Co., and *for mail*, 3233 Park View Ave., Pittsburgh, Pa.

SMITH, William H. (1911), Genl. Mgr. and Secy., John R. Keim Mills, Inc., and *for mail*, 52 W. Oakwood Pl., Buffalo, N. Y.

SNYDER, William R. (Junior, 1911), Supt., Fulton Bag & Cotton Mills, 236 Spring St., New York, N. Y.

SPENCER, C. C. (1911), Supt., Westinghouse Church Kerr & Co., 10 Bridge St., New York, N. Y.

STANFORD, J. Verne (1911), Asst. Prof. Mech. Engrg., Univ. of Pa., and *for mail*, 5121 Chestnut St., Philadelphia, Pa.

STRAUB, Albert A. (Junior, 1911) Asst. Ch. Engr. of Power Stations, Pittsburgh Rys. Co., and *for mail*, 417 Hastings St., Pittsburgh, Pa.

STUBBLEBINE, Winfred Albertis (1911), Engr., The Lehigh Fdy. Co., Fullerton, Pa.

SVENSEN, Carl Lars (Junior, 1911), Instr. Mech. Engrg., Tufts College, Tufts College P. O., Mass.

THROCKMORTON, George Kenneth (Junior, 1911), Merchandise Examiner, Sears, Roebuck & Co., and *for mail*, 3830 W. Adams St., Chicago, Ill.

THURMAN, Charles Ross (1911), Ch. Engr., Elec. Renovator Mfg. Co., and *for mail*, 431 Amberson Ave., Pittsburgh, Pa.

TODD, James (1911), Pres. and Ch. Engr., The Sterling Varnish Co., Pittsburgh, Pa.

UTLEY, Joseph Cole (Junior, 1911), Steam and Hyd. Engrg. Dept., Natl. Tube Co., and *for mail*, P. O. Box 358, McKeesport, Pa.

VOSBURY, W. DeWitt (1911), Mech. Engr., P. O. Bldg., Darby, and *for mail*, Colwyn, Pa.

WACHS, Theodore (Junior), 1911, Asst. Production Engr., Sears, Roebuck & Co., and *for mail*, 2725 Pine Grove Ave., Chicago, Ill.

WALTON, Albert (Associate, 1911), Shop Systematizer and Expt. Accountant, M. Rumely Co., La Porte, Ind.

WARDER, Walter J., Jr. (1911), Crocker Wheeler Co., Ampere, N. J.

WEBSTER, William Ralph (1911), Designer and Squad Foreman of Checkers, Cambria Steel Co., and *for mail*, 542 Horner St., Johnstown, Pa.

WILSON, Chester Worcester (Junior, 1911), 25 Emmons Pl., New Britain, Conn

PROMOTIONS

BOUGHTON, Judson H. (1903; 1911), Pres., Natl. Light & Power Co., Pierce Bldg., and 6343 Berlin Ave., St., Louis, Mo.

CASTLE, Samuel Northrup (1909; 1911), Genl. Elec. Co., 30 Church St., New York, N. Y.

DREYFUS, Edwin D. (1905; 1911), Commer. Engr., The Westinghouse Mch. Co., East Pittsburgh, and 422 Hampton Ave., Wilkinsburg, Pa.

HOGLE, Milton, W. (1901; 1906; 1911), Asst. Wks. Mgr., The T. H. Symington Co., and *for mail*, 128 Linden St., Rochester, N. Y.

McMULLEN, Vincent E. (1907; 1911), Genl. Foreman Gas Eng. Dept., Fairbanks, Morse Mfg. Co., and *for mail*, 1251 Josephine Ave., Beloit, Wis.

PHETTEPLACE, Thurston M. (1904; 1911), Asst. Prof. Mech. Engrg., Brown Univ., and *for mail*, 1596 Broad St., Providence, R. I.

DEATHS

DAVIS, Thomas B , November 3, 1911.
FERRIER, Joseph J., October 30, 1911.
HASKINS, Caryl D., November 18, 1911.
JOHNSON, Warren S., December 5, 1911.
MIX, Edgar W., November 12, 1911.
SALTER, Thomas Fitch, October 25, 1911.

COMING MEETINGS

JANUARY–FEBRUARY

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading, and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
December 27–January 3, annual meeting, Washington, D. C. Secy., L. O. Howard, Smithsonian Institution.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
January 12, monthly meeting, 29 West 39th St., New York. Secy., F. L. Hutchinson.

AMERICAN SOCIETY OF CIVIL ENGINEERS
January 17–18, annual meeting, New York. Secy., Chas. Warren Hunt, 220 West 57th St.

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS
January 9, annual meeting, New York. Secy., J. R. Wemlinger, 13 Park Row.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
January 23–25, annual meeting, 29 West 39th St., New York. Secy., W. W. Macon.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Monthly Meetings: New York, January 9; Boston, January 15; San Francisco, January 15. Secy., Calvin W. Rice, 29 West 39th St., New York.

CEMENT PRODUCTS EXHIBIT
January 29-February 3, exhibit, New York. Office, 72 West Adams St., Chicago, Ill.

ENGINEERS SOCIETY OF WESTERN PENNSYLVANIA
January 16, annual meeting, Pittsburgh, Pa. Secy., Elmer K. Hiles, 2511 Oliver Bldg.

SOCIETY OF AUTOMOBILE ENGINEERS
January 18–20, annual meeting, New York. Secy., Coker F. Clarkson, 1451 Broadway.

NEW ENGLAND WATERWORKS ASSOCIATION
January 10, annual meeting, Hotel Brunswick, Boston, Mass. Secy., Williard Kent, Narragansett Pier, R. I.

WOOD PRESERVERS' ASSOCIATION
January 16–18, annual meeting, Chicago, Ill. Secy., F. J. Angier, Mount Royal Station, Baltimore, Md.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
January			
4	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
9	American Society of Mechanical Engineers	C. W. Rice	8.15 p.m.
11	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
12	American Institute of Electrical Engineers	F. L. Hutchinson (Acting Secy.)	8.00 p.m.
16	New York Telephone Society	T. H. Lawrence	8.15 p.m.
19	New York Railroad Club	H. D. Vought	8.15 p.m.
23–25	American Society of Heating and Ventilating Engineers	W. W. Macon	All day
24	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
February			
1	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
8	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
9	American Institute of Electrical Engineers	F. L. Hutchinson (Acting Secy.)	8.15 p.m.
13	American Society of Mechanical Engineers	C. W. Rice	8.15 p.m.
16	New York Railroad Club	H. D. Vought	8.15 p.m.
28	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.

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H. F. J. PORTER (1), *Chmn.*
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L. R. POMEROY (1), *Chmn.*
C. E. LUCKE (2)
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W. E. HALL (4)
C. J. H. WOODBURY (5)

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L. WALDO (1), *Chmn.*
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C. L. CLARKE (3)
A. NOBLE (4)
E. G. SPILSBURY (5)

Public Relations
J. M. DODGE (5), *Chmn.*
R. W. HUNT (1)
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J. W. LIEB, JR. (3)
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Note—Numbers in parentheses indicate number of years the member has yet to serve.

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CHARLES KIRCHHOFF

Engineering Education
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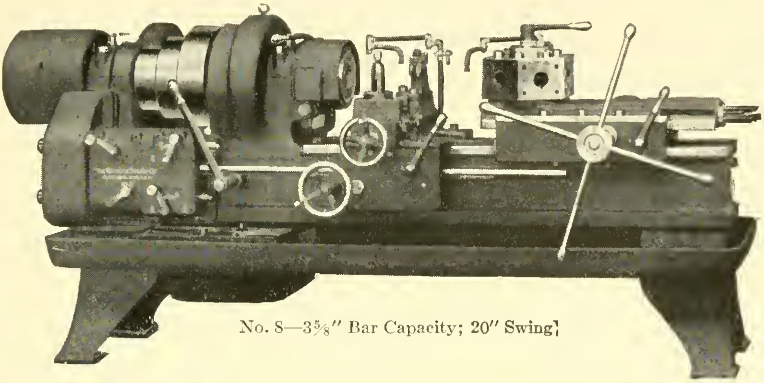

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FIG. 1 illustrates the advantage of the *double stop* for each position of the turret, and the *double* adjustment of each turner. This piece has six finished diameters and six shoulders, and is turned by only three turners, which occupy only three positions on the turret. This not only leaves the remaining positions free for other tools, but it saves the operator the time and energy required to run the turret slide back each time.

All this is obtained without complication, and without introducing any features that are annoying when not in use.

In addition to the double stop for each of the six positions of the turret, we have an extra stop, consisting of a pin which may be dropped into any one of the six holes at the rear of the turret slide. This makes it possible to borrow five extra stops for any one of the tools, and gives to this tool seven length or shoulder stops, and leaves one stop for each of the remaining tools.

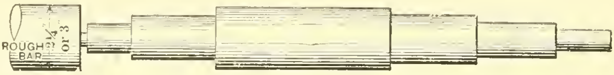

FIG. 1

The illustrations, Figs. 2 and 3, give examples of what one tool can do in this machine on chuck work, when we take advantage of the seven length stops and the seven shoulder stops of the cross-feed head.

Of course, in general practice three or four stops for one tool are all that will be needed, but since the modern cutting steels have greater durability, there is nothing lost by giving each tool all the work it can do.

Outer face and all shoulders and diameters accurately finished to independent stops by one tool. When roughing and finishing cuts are required, the roughing tool can be set near enough to use the same stops that are accurately set for the finishing tool. When an extra tool is used to give a roughing cut it is set as indicated by dotted lines in Figs. 2 and 3.

We find it difficult to illustrate all of the classes of work that can be turned out by this machine, but a little thought will suggest

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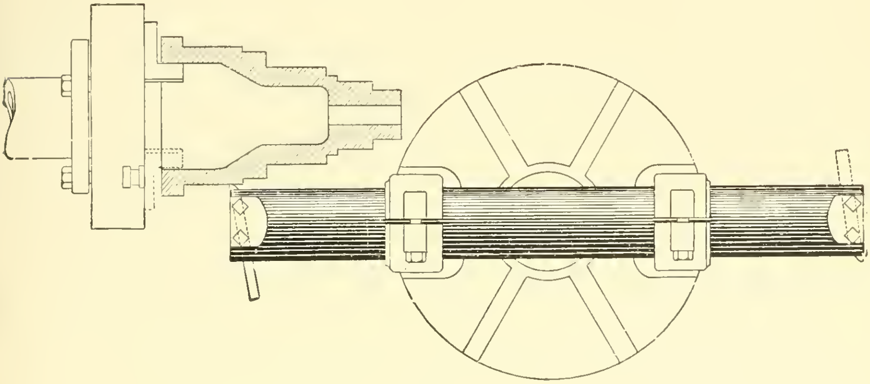

Fig. 2

many forms that may be readily handled in bar and chucking work, both steel and iron, on account of the many provisions for bringing both turret and cross slide up to fixed stops; either by power feed or by hand.

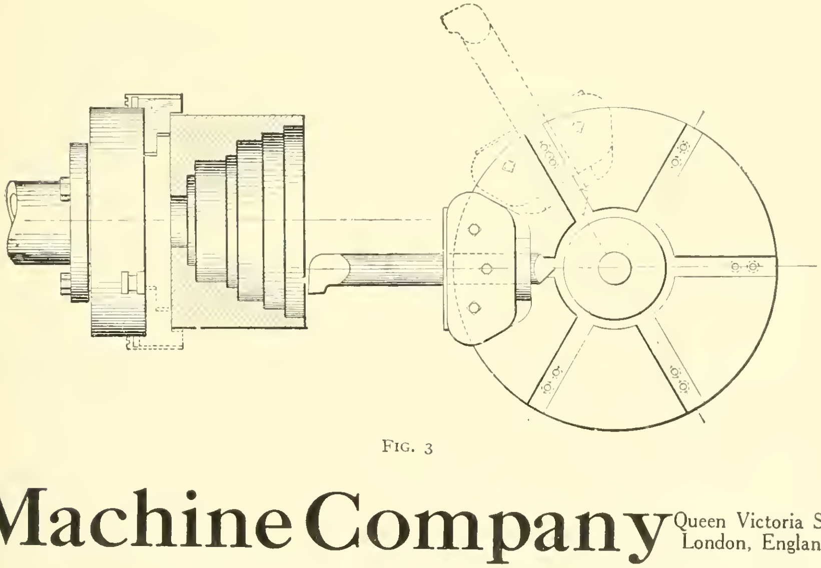

Fig. 3

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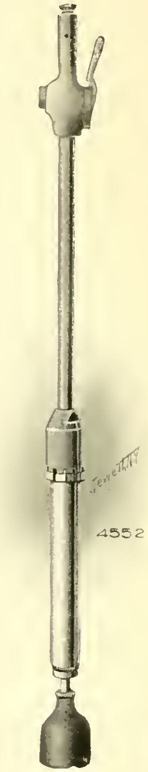

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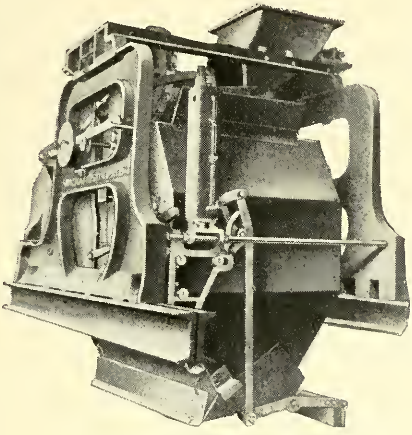

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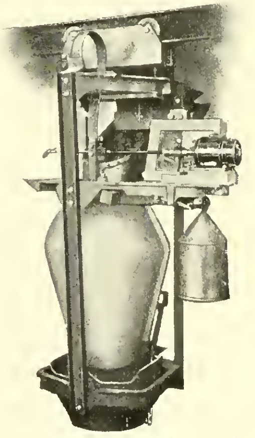

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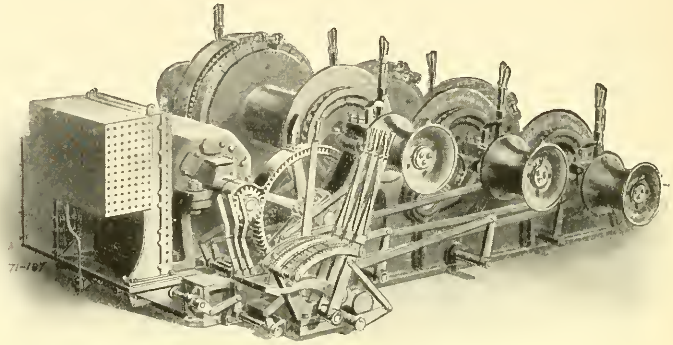

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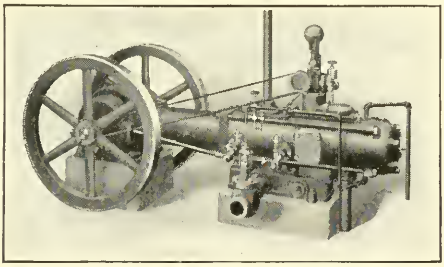

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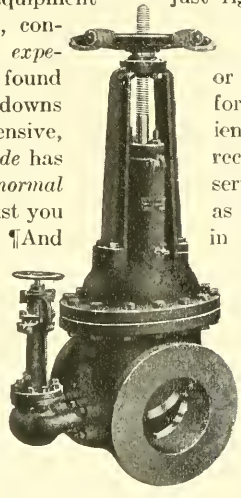

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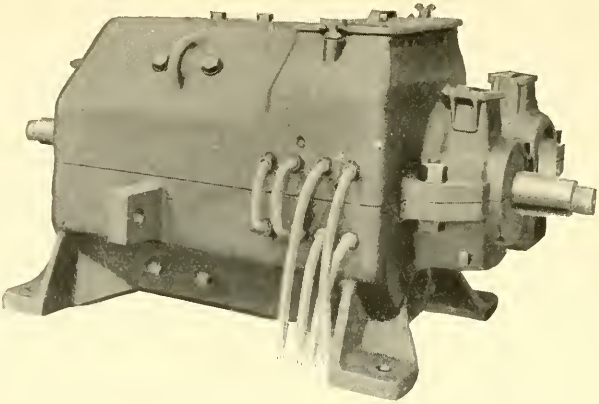

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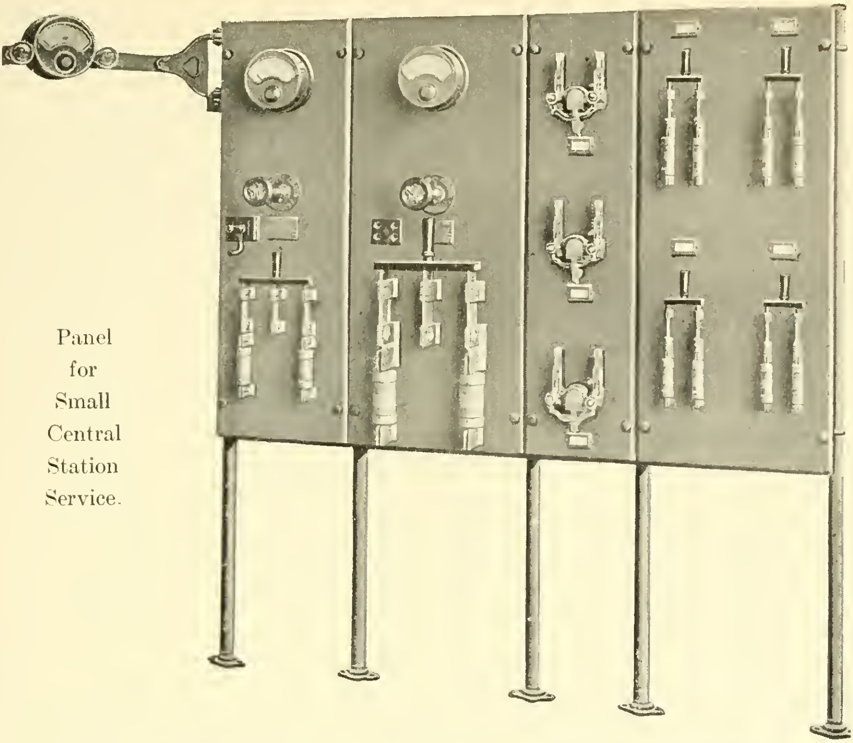

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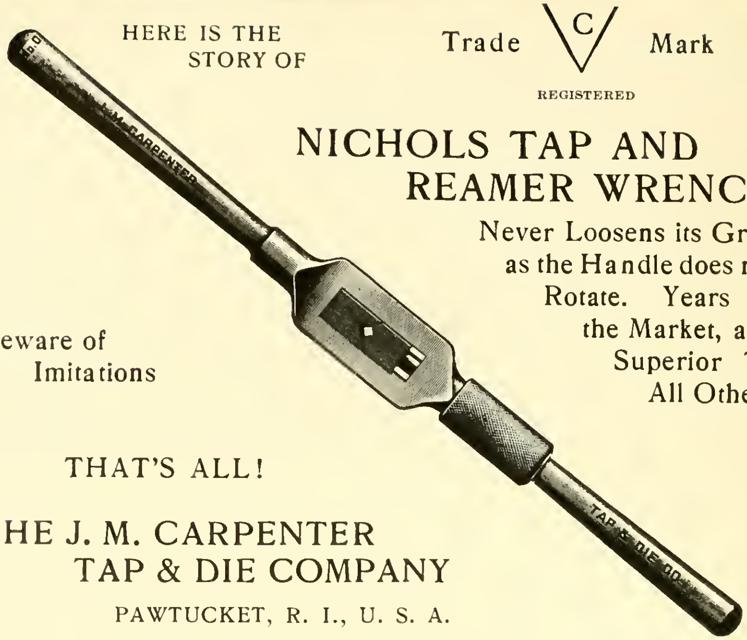

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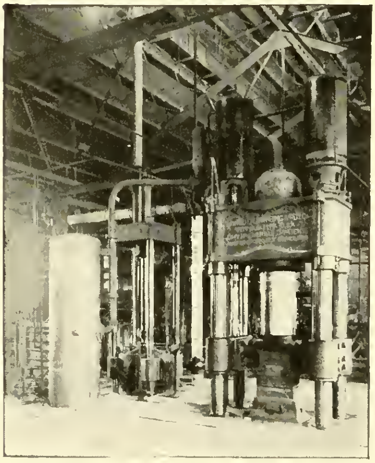

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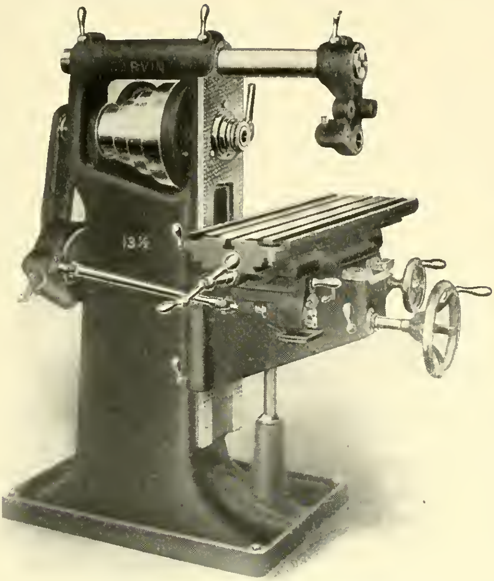

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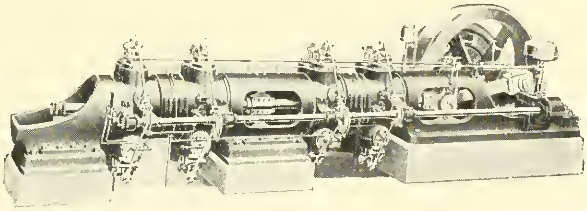

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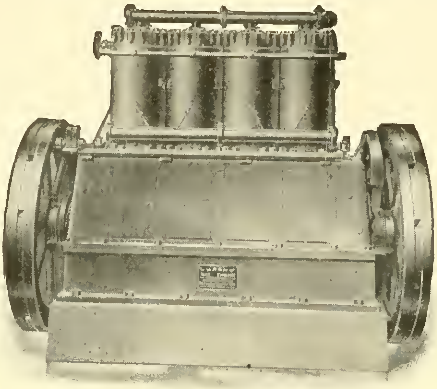

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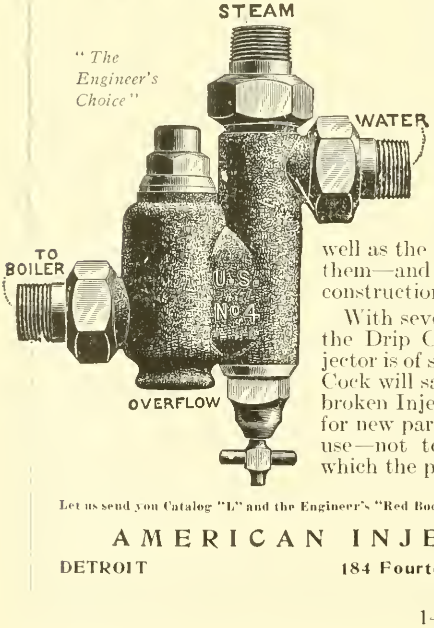

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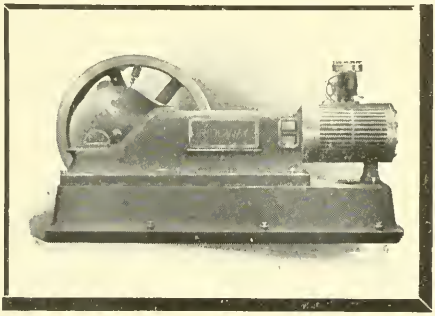

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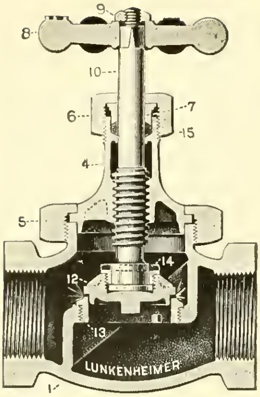

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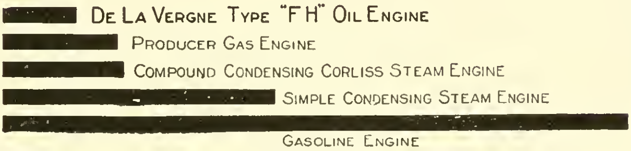

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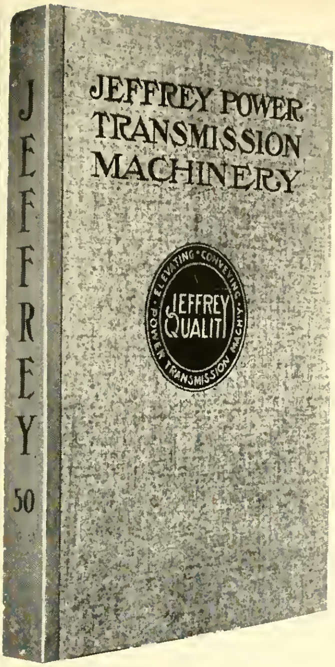
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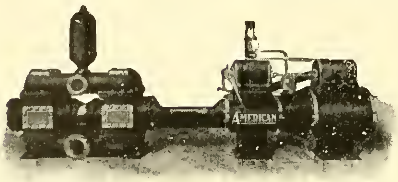

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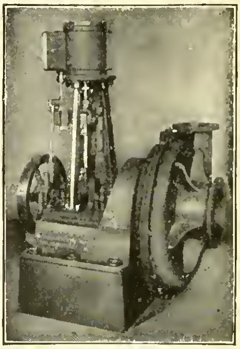

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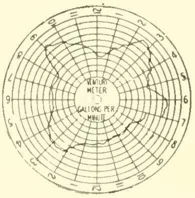

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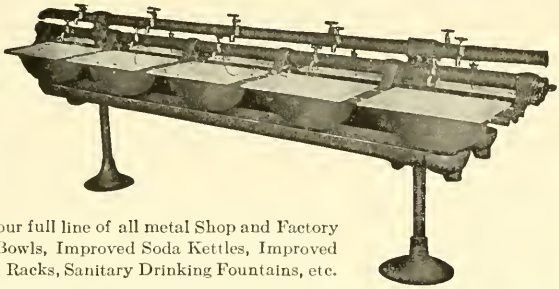

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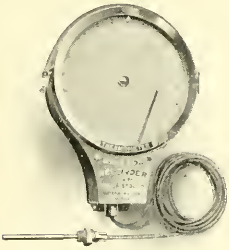

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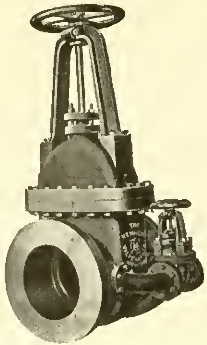

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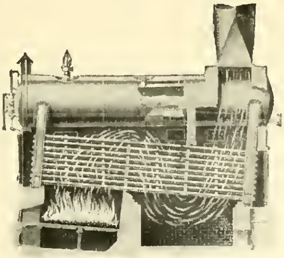

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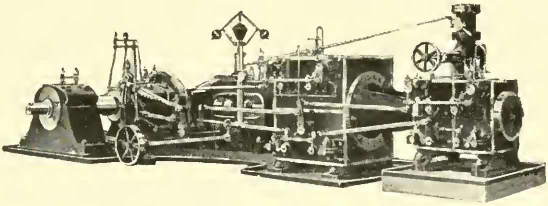

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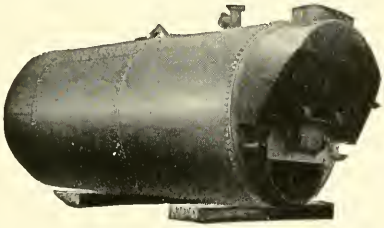

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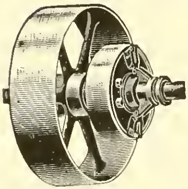

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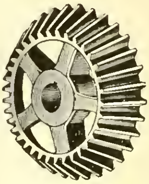

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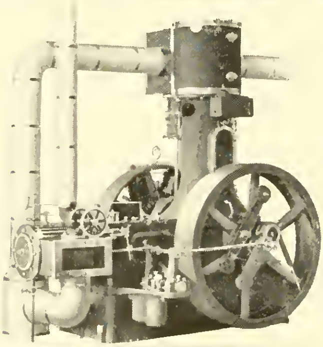

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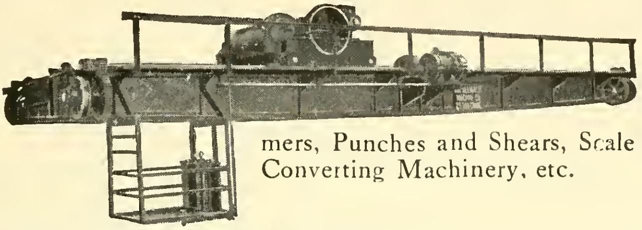

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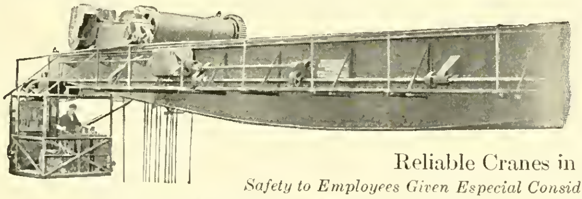

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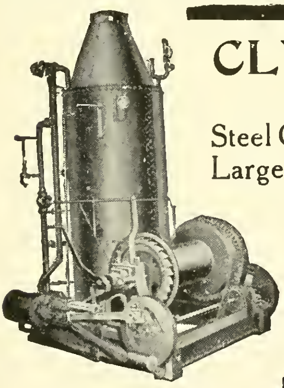

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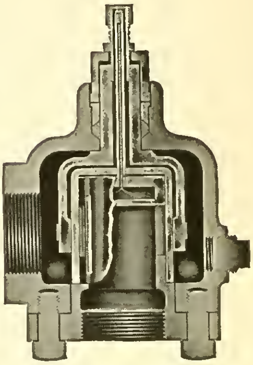

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FEBRUARY 1912

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ISSUES OF THE JOURNAL WANTED

The Society wishes to secure copies of the following issues of The Journal: Mid-November 1906, Mid-October 1907, May 1908, October 1909, October 1910, January 1911. These will be purchased from members at 25 cents a copy, provided they are in good condition.

COMING MEETINGS

NEW YORK MEETING, FEBRUARY 13

The American Institute of Mining Engineers will coöperate in a meeting of the Society in New York, February 13, in the Engineering Societies Building. A paper of interest to both branches of the profession, entitled, Notes on Design and Mechanical Features of the California Gold Dredge, by Robert E. Cranston, consulting engineer for the Marysville Dredging Company, Marigold, Cal., will be presented. The author has made a careful study of the subject and the paper is fully illustrated with diagrams and data, drawn from dredges in use in California.

The paper will be discussed by Charles Whiting Baker, Editor of Engineering News; and by B. B. Lawrence, Julius A. Lewisohn and A. P. Rogers, Members A. I. M. E., of New York; and others.

It is anticipated that this paper will also be discussed at a meeting of the Society in San Francisco at an early date, and that the viewpoints brought out at these two meetings should prove to be a valuable symposium.

BOSTON MEETING, FEBRUARY 16

A meeting of the Society will be held in Boston on February 16. A topical discussion on Aviation will occupy the evening, the opening paper being presented by A. A. Merrill.

ST. LOUIS MEETING, FEBRUARY 7

A meeting of the Society will be held in St. Louis on February 7, in which the other engineering societies will be invited to coöperate. A paper will be presented entitled, A Comparison of Air Braking Systems for Urban Electric Railway Cars, by Messrs. Hobein and Young of the United Railways Company of St. Louis.

NEW COMMITTEES IN BOSTON AND NEW YORK

At a meeting of the members of the Society resident in Boston and vicinity, on January 16, the following committee were chosen to act as the Committee on Meetings in that city for the current year: E. F. Miller, Chairman; R. E. Curtis, Secretary; R. H. Rice, Henry Bartlett, George F. Swain. This committee has been approved by the Council.

H. R. Cobleigh has been elected upon the New York Committee on Meetings, to take the place of Walter Rautenstrauch, who has been obliged to resign because of other duties.

REPORTS OF MEETINGS

ENGINEERS' DINNER IN BOSTON

The third of a series of annual engineering dinners took place in Boston, on January 15, at the Hotel Somerset. The responsibility for the arrangements rested this year with the Boston Society of Civil Engineers, the Boston Section of the American Institute of Electrical Engineers and The American Society of Mechanical Engineers coöperating in the plans. There was an attendance of about 400 engineers from the locality of Boston, and a spirit of cordiality was everywhere in evidence.

Charles T. Main, Mem. Am. Soc. M. E., President of the Boston Society of Civil Engineers, presided, and in his opening remarks referred to the important and influential position of the engineering profession and spoke of the value of social intercourse between its members.

Ira N. Hollis, Mem. Am. Soc. M. E., president of the new Engineers' Club of Boston, was then introduced. He spoke of the necessity of the emphasizing and fostering of unity throughout the engineering profession by intimate contact between its various groups. He told also of the progress made by the new club which had been incorporated and had chosen a strong Board of Governors. An option had been secured upon some property on Commonwealth Avenue facing the public gardens, an unsurpassed location for convenience and attractiveness of surroundings, which would be suitably altered to provide the usual facilities, and also an auditorium sufficient for ordinary gatherings, as well as quarters for the office and library of the Boston Society of Civil Engineers. It seemed probable that the full quota of members permitted by the By-Laws would soon be secured.

General Hugh Bancroft, chairman of the recently appointed Directors of the Port of Boston, was the next speaker, and dwelt particularly on the work confronting the directors. Large and important as might be the problem of providing new docks and terminal facilities, the development of business to utilize them was even greater. The opening of the Panama Canal, he prophesied, would make ports situated like Boston of more value than inland centers, and such a condition should insure the local support of enterprises tending to develop commerce at this port. He recommended that the water front should be the property of the public rather than of private individuals, in order to utilize the harbor facilities properly, and referred in conclusion to the intimate relation between the adequate development of the port and the industrial growth and prosperity of the state.

President Main then called upon representatives of the three local technical schools, emphasizing the close relation between these schools and the industrial and engineering interests of the locality.

Prof. W. C. Sabin, Dean of the Graduate School of Applied Science of Harvard University, spoke of the necessity for scientific training to keep in touch with the problems of the day, and referred to the experimental work with large scale models which had been done on the continent of Europe in connection with the study of river and harbor problems, and suggested the development of similar courses and laboratories in this country, so that such engineering work might be based upon a definite action of tides, currents, etc., with relation to the character of soil, conformation of shores, etc., substituting thereby scientific for empirical methods.

Dr. Richard C. Maclaurin, President of Massachusetts Institute of Technology, said that the institute also, like the new club, found itself confronted with a housing problem, which it hoped to work out in an efficient and worthy manner. He referred to a suggestion which had been made that the institute model its new buildings after factory construction, and argued that advantage should be taken to the utmost of types of construction specially developed and proved to be satisfactory for industrial purposes, with the proviso that regard should also be paid to beauty of outline and architectural treatment, in order that the buildings should have a dignity which might suitably express the work and position of the institute in the community.

President F. W. Hamilton of Tufts College said that although as a non-technical man he might appear at a disadvantage in addressing a gathering of engineers, the fundamental principle of education was nevertheless the same, that of teaching the individual to think clearly and definitely and enabling him to attack his life's work with credit to himself and service to his community.

The greetings of the national engineering societies were extended by Admiral M. T. Endicott, President of the American Society of Civil Engineers; Colonel E. D. Meier, Past-President and Honorary Vice-President of The American Society of Mechanical Engineers; and Dr. Gano S. Dunn, President of the American Institute of Electrical Engineers, each of whom cordially indorsed the gathering together of engineers for intercourse and urged greater participation in public matters where they might serve the community.

NEW YORK MEETING, JANUARY 9, 1912

The January meeting of the Society in New York was unique among such meetings, and for that reason one of the most interesting that has been held. It was a "get-together" meeting for a statement of plans and policies by members of the various standing committees and of the Committee on Meetings in New York, and for a free discussion of these policies from the floor.

The Society is characterized at the present time by marked activity all along the line on the part of the various committees, and by the individual interest of many of its members. It was to acquaint the local membership with these developments and further to enlist their interest that this meeting was called.

The meeting was opened by Professor Walter Rautenstrauch, of the Committee on Meetings in New York. He introduced the President, Dr. Alexander Humphreys, who made the opening address and afterwards presided.

Dr. Humphreys took as his text a remark by Professor Rautenstrauch to the effect that ten per cent of the success of a project is due to its inception, while ninety per cent depends upon putting it into effect. He was in accord with the idea of making the Society more useful, but the question was, how can it be done thoroughly? There are obligations to be met, as for example the retirement of the certificates recently issued to the membership, provision for which has to be made out of the income of the Society. He favored the extension of meetings and discussed the possibility of the appointment of sub-committees to cover different activities in the field of mechanical engineering, as recently proposed by the Committee on Meetings, but said we should undertake only such work as we can do thoroughly, and at least the work should be planned with the evidence of careful thought.

With respect to the conduct of meetings, the Annual and Spring Meetings of the Society are under the control of the general Committee on Meetings, while the local meetings in different cities are under the direct control of the Council, this arrangement having been decided upon because these latter meetings are a new feature in the activities of the Society, and the Council does not yet know how to instruct the Committee on Meetings as to policy and method of management.

Dr. Humphreys discussed in detail various plans that had been proposed for raising funds for the entertainment at the Annual Meeting. At present this is done by subscriptions solicited from the membership in the New York district, and the Committee on Meetings in New York recently suggested an amendment to the Constitution to the effect that there should be a separate organization of the New York members in respect to annual dues and that every member within this district should pay an extra fee. The Council did not think this plan would be fair, as a man living here might be so situated that he could not take advantage of the local benefits and still he would be charged with this additional sum. He suggested that if it is still to be done by subscription, we would get better results if the amount asked for were limited to a specified sum, thus attempting to place the burden on a considerable number instead of on a few.

In the American Gas Light Association the difficulty is overcome by asking every member in advance of the meeting whether he is going to attend and for how many guests he will wish to provide.

Tickets are then provided him for the entertainment desired, and he is charged with a corresponding sum.

Dr. Chas. E. Lucke of the Committee on Meetings followed, outlining the functions of the Committee on Meetings during the past two years. Originally this committee had the double duty of the solicitation and judging of professional papers, and the management of all meetings.

At that time meetings were held only in New York, aside from the Annual and Spring conventions. With the extension of meetings to other cities, however, the problem of management became more difficult. Restrictions imposed by the officers of the Society on the conduct of meetings were in some cases objected to. Members in one section felt they were as well able to uphold the standards of the Society as were members in another section The Council finally took the management of these local meetings entirely out of the hands of the Committee on Meetings and began by removing all restrictions, to which the speaker objected on the ground that while each city might be able to maintain a standard of its own, the standards in different localities differed.

Having been relieved of these responsibilities, the committee devoted more attention to its other work, the solicitation of papers. Investigation made it plain that the Transactions of the Society were not reflecting the practice of mechanical engineering broadly. It appeared clear that the Committee on Meetings, of five ordinary members, were not competent to judge all things in mechanical engineering. A paper had seldom been turned down that did not raise a storm. Ocassionally an expert was called in, but he did not like to be criticised either, and it was finally decided to recommend a series of sub-committees, so that if a man presented a paper that dealt with the engineering problems of the textile industry for example. he would know that it would be submitted to a committee of men representative of that industry But why limit these committees to mere reference duties when they might be more valuable to the Society if, instead of merely asking them to tell what is good or bad among the papers submitted, they were to take the initiative and say what should or should not be treated at our meetings? It was with these ideas that the committee proposed to the Council to have a large number of sub-committees appointed. The membership was asked for suggestions of names for the committees and they are now being tabulated. but cannot be announced until the Council has determined upon a plan for their management.

Frederick A. Waldron, in speaking for the New York Committee, asked if it would not be advisable to make this a continuing committee in rotation, one member retiring and a new member appointed each year. One of the important problems is the raising of enthusiasm and interest on the part of the 1100 local members, in order to insure a reasonable attendance at the monthly meetings in New York. Boston meetings have a higher average attendance than New York meetings. There are no doubt ample reasons for this, owing to the peculiar conditions existing in New York, such as specialization of engineering work and the distance of the suburbs from the center of the city.

In respect to finances, which are so important an element in the committee's work, money must be obtained for two distinct purposes. First, there is an appropriation by the Society for defraying the expenses of the monthly meetings, which must be conducted within the limits required by the Constitution and By-Laws. These preclude the expenditure of money for social entertainment. Under the present arrangement money must be raised by subscription by this committee for the purpose of entertaining the visiting guests of the Society at the Annual Meeting. Various facts relating to the raising of this sum and to its expenditure (pertinent only to the local membership) were discussed by the speaker, who mentioned five ways by which the fund could be raised, all of which, he said, were open to more or less objection. These are as follows: (*a*) By increasing annual dues of local members; (*b*) by voluntary subscription on the part of local members; (*c*) by an underwriting organization in which prominent members of the Society would underwrite the expenses for the social features and obtain the money by whatever method the organization might see fit, making it really a permanent organization of the Society; (*d*) by the classification of business houses in the city from whom subscriptions would be solicited, no house to be called upon to subscribe oftener than once in three years; (*e*) by the pay-for-what-you-get method for both local and visiting members, which while attractive from the financial side cannot appeal to one strongly on the score of hospitality.

Fred R. Low, for the Publication Committee, explained that in the earlier days it was possible to include in the annual volume of Transactions everything said and done at the various meetings. This is no longer possible. The last volume, after drastic editing and the exclusion of much really pertinent matter, contained over fifteen hundred pages, which is about the limit both as to bulk and expenditure. It is the purpose to make this annual volume of Transactions of the utmost possible permanent value and the test applied in discarding surplus material should be its probable usefulness to the man who gives it place on his shelves. Measured by this scale, it is possible that records of business sessions, reports dealing with the internal affairs of the Society, which are of no technical value and of only temporary interest, might find all the necessary publicity in the columns of the monthly Journal.

In The Journal, papers to be presented at the regular meetings are printed, most of them considerably in advance of the time of presentation, affording an opportunity for more deliberate and mature discussion. The Society has adopted the broad and liberal policy toward the technical press of releasing this material for publication before it has been formally presented at a meeting. Some of the societies which have publications of their own will not allow the technical press to print their papers or report their discussions until they have been given at public meetings.

But even in The Journal, it is not possible to print all of the papers presented at the various local meetings in the different cities, nor can all of the discussions given at these meetings be published. Notwithstanding the insufficiency of space for the complete presentation of our doings, the Publication Committee have initiated a movement for keeping readers in touch with the activities of the old world in the field of mechanical engineering. Foreign periodical literature coming to the library is gone over by a competent person and abstracts of articles made for publication in The Journal. Through the liberal patronage of its advertising pages The Journal is now self-supporting and the Society has again shown its breadth of view and appreciation of its real objects by offering it to the public practically at cost. An effort has been made to give a distinctive character to its advertising pages, in keeping with that of the Society, by the presentation of data valuable to engineers, regarding the apparatus advertised. Some three hundred pages of such material was secured last year in addition to the ordinary display advertising, and these are shortly to be issued in a separate volume for distribution to the membership.

Hosea Webster for the Membership Committee said that its chief work was the scrutinizing carefully of the qualifications of those who applied for membership. He suggested several ways in which lost motion might be eliminated and the nature of the requirements be made more explicit, but was not prepared to make definite recommendations.

Dr. Leonard Waldo for the Library Committee, referred to the growth of the library of the Engineering Societies since it has been installed in its present location and of the many difficulties to be overcome. He spoke of his visit to various libraries in Germany during the past two summers and in particular of the excellent library of the Krupp works, where they have five or six hundred assistants on the library staff and hand out over two thousand books a day. He explained the desirability for coöperation between our library and the Astor library in the New York Public Library building almost across the way and that some of the expensive reference works could better be placed there than here. Every courtesy is shown those wishing to investigate engineering matters, and engineers who have become accustomed to consulting our library never wish to go elsewhere for such purpose. We are making systematic lists of fine books and as rapidly as the money can be secured it is being invested in that direction. We mean to have it so that when a request comes from any source for engineering information, the person will be able to receive the last word on the subject, whether he makes the request in person or in writing from a distance.

Edward Van Winkle, for the House Committee, outlined its work, beginning in 1907 by re-arranging the rooms, supplying new furniture and furnishings to a considerable extent, and in systematically grouping the portraits on the walls. The plan, as now carried out, is to hang the portraits of prominent engineers on the walls of the Council room, which is the first room entered upon leaving the elevator. The second room, used as a ready reference library, was set aside for a set of pictures of past-presidents, and the third room, the Secretary's office, for pictures of Honorary Members. It has been the aim of the committee to give the decoration of the rooms a personal touch such as would be given in the home.

A written statement was read by the Chairman of the Finance Committee, R. M. Dixon, showing the assets of the Society to be approximately $700,000, due largely to the generosity of Mr. Carnegie in his gift of the Engineering Societies building. The Society has no indebtedness aside from its funded debt of $81,000 represented by certificates of indebtedness which are to be retired year by year from the income. In 1900, the income of the Society was approximately $30,000. In 1911 it was approximately $97,000, and during the eleven years the expenditures with one exception have been held within the income. At the beginning of each year, the Finance Committee presents to the Council a budget containing the appropriations for the various activities for the ensuing year. The present Finance Committee is of the opinion that it is none too conservative to base this budget upon a ten per cent margin of safety under the estimated income, and the appropriations for the current year have accordingly been made on this basis.

During the meeting there was considerable general discussion from the floor mostly upon various methods for raising funds for defraying the expenses of the entertainment at the annual meetings. There was the usual diversity of opinion upon the subject, different members favoring certain phases of the plan suggested by Mr. Waldron in his address on this subject, the sentiment being divided between increasing the dues of the local membership and continuing the present policy of soliciting subscriptions annually.

MEETING OF THE COUNCIL

A meeting of the Council was held in the Society rooms, on the afternoon of Tuesday, January 9, 1912. There were present: Alex. C. Humphreys, President, presiding, Ira N. Hollis, Jesse M. Smith, James Hartness, Henry Hess, Stanley G. Flagg, E. D. Meier, George A. Orrok, H. G. Reist, R. M. Dixon, Chairman of the Finance Committee, and the Office Manager representing the Secretary. Dr. Waldo, Chairman of the Library Committee, was present by invitation. Letters of regret were received from H. H. Vaughan, E. B. Katte and D. F. Crawford.

Voted: To approve the minutes of the meeting of December 8, 1911, as read.

The Secretary reported the death of Warren S. Johnson of Milwaukee.

Voted: To accept the following resignations: F. H. Niles, A. J. Hill, George G. Hopkins, Jr., F. J. Hale, James U. Norris.

The President made announcement of the following appointments on Standing and Special Committees: House, W. N. Dickinson; Library, Leonard Waldo (reappointed); Meetings, H. E. Longwell and H. L. Gantt; Membership, H. C. Meyer, Jr.; Public Relations, Worcester R. Warner; Research, A. L. DeLeeuw, Richard H. Rice (reappointed); Committee on Cöoperation with Other Societies, E. D. Meier, C. W. Baker.

The Secretary reported the election of an Executive Committee by letter ballot, in accordance with instruction of the Council, to consist of Alex. C. Humphreys, President, ex-officio, F. R. Hutton, E. D. Meier, George A. Orrok, H. G. Reist and H. G. Stott.

The President presented a letter of resignation from H. G. Stott.

Voted: That Mr. Stott's resignation as a member of the various committees on which he is serving be accepted with great regret, but that he be requested to allow his resignation as Manager to be withdrawn.

Voted: That E. B. Katte, standing next in the order of votes received, be appointed a member of the Executive Committee to serve in the place of H. G. Stott whose resignation has been presented.

Voted: To approve and confirm the appointment by the Boston membership of E. F. Miller, R. E. Curtis, Richard H. Rice, Henry Bartlett, and George F. Swain, as a Committee on Meetings of the Society in Boston.

Voted: To refer to our Committee on Coöperation with Other Societies, the communication of Mr. Herbert E. Ives, Chairman of the Committee on Reciprocal Relations of the Illuminating Engineering Society.

A report from H. G. Stott, Chairman of the Committee on Revision of the Standard Schedule of Flanges, was read.

Voted: To adopt the recommendations of the Chairman that the report be printed in The Journal and leaflet form for distribution and that the Committee be discharged with thanks.

Voted: To refer to the Executive Committee with request to report back to the Council, the question of the status of the Committee on Constitution and By-Laws and that the Executive Committee ask the coöperation of Mr. Smith.

Voted: That regular meetings of the Council be held on the second Tuesday of each month at three o'clock in the afternoon.

Voted: That during the absence of the President and Treasurer, Ira N. Hollis, Vice-President, senior by age, be authorized to sign checks.

Voted: That it be referred to a committee to advise in the matter of a definite amendment to the Constitution which will define strictly the duties of the various officers of the Council and the assignment of their duties when for various causes they are not available.

On motion adjourned to Tuesday, February 13.

CURRENT AFFAIRS OF THE SOCIETY

That the members of the Society living at a distance from headquarters might feel that their interests were of equal importance to the officers and council of the Society, the Council sent the Secretary to San Francisco to attend a conference of local representatives from nine national societies, called to consider the advisability of holding a general engineering congress in 1915. The date of the proposed congress has been selected with reference to the opening of the Panama Canal, a great engineering achievement.

On his way to attend the conference the Secretary visited many of the Student Branches, including the University of Cincinnati, Ohio State University, the University of Kentucky, Washington University, the University of Missouri, the University of Nebraska, and the University of Illinois, and met the membership in many of the principal cities en route.

In Buffalo, on January 3, the first meeting ever held in that city under the auspices of the Society brought out an attendance of 200, representing different branches of the profession. In addition to the address by the Secretary, a paper was read by John Calder on the Economic Administration of Industrial Establishments, in which he spoke of the need for greater efficiency, and said that the organization of such an establishment was the primary consideration rather than the system, which should be used as a means, not as an end.

Members of the Society also met to greet the Secretary in Cincinnati, on January 4, and in St. Louis an informal dinner and reception were given on January 6. Similar meetings were held in San Francisco, Denver, and Chicago. At the Chicago meeting an address was made by R. H. Hunt, Past-President.

The benefits, to students on the one hand, of the student engineering societies, and the duty, on the other hand, of the national societies to interest themselves in the work of educating engineers need not even be stated.

With the older members of the Society the good to be secured from meetings needs to be repeatedly brought out. Because of many demands, it often happens that a member may have been associated with a society for a dozen years without ever having attended a meeting or knowing the other members living in his own city.

At these meetings the Secretary has been able to present the many activities of the Society and mention its very practical benefits, such as those from the large technical library and its staff of trained workers, ready to make searches in any engineering subject. For simple searches requiring only bibliographies of articles on subjects appearing in current technical periodicals, 700 of which are received in the library, and of titles of books in the library, no charge is made. This service is free alike to the members of the American Institute of Mining Engineers, the American Institute of Electrical Engineers, and The American Society of Mechanical Engineers, whose libraries are combined in the United Engineering Library.

In our own Society there is another service at the disposal of the membership, that of the employment bureau. Firms desiring the services of competent engineers in any line may obtain a list of such engineers; and, vice versa, members of the Society desiring to improve their situation or others seeking a position may often secure opportunities. This service is absolutely free and is confidential, the work being personally conducted by the Secretary.

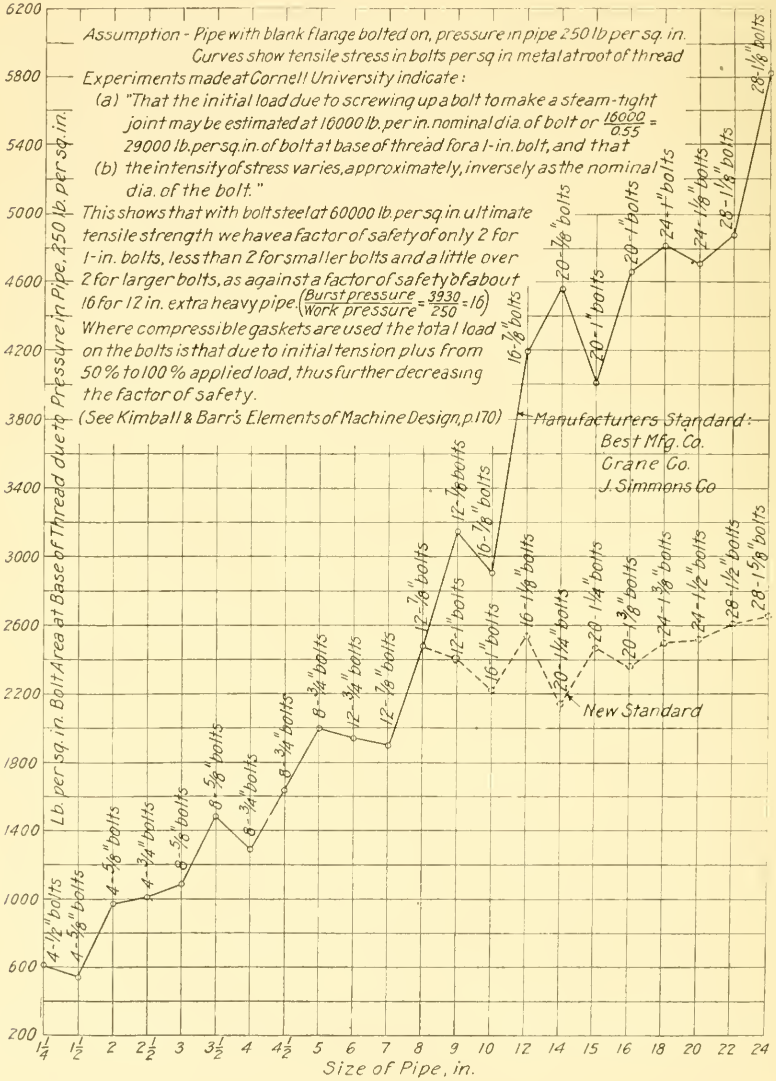
Calvin W. Rice, *Secretary*

REGARDING THE REPORT ON FLANGES

In connection with the report of the Committee on Flanges, published in this number, the accompanying chart is given showing stresses in the bolts at the base of the thread due to a pressure in the pipe of 250 lb. per sq. in. The chart was plotted by the committee in order to indicate graphically the extent to which these stresses increase with the sizes of the pipe in the Manufacturers' Standard, and the dotted lines show the departure made from the latter in the New Standard in order to keep the stresses down to what is considered by them to be a safe limit, and shows clearly the reason for the radical changes made in the larger sizes.

At the annual meeting of the American Society of Heating and

Ventilating Engineers held last month, a committee examined the new schedule of standard weight and extra heavy flanged fittings



Assumption - Pipe with blank flange bolted on, pressure in pipe 250 lb per sq. in. Curves show tensile stress in bolts per sq in metal at root of thread

Experiments made at Cornell University indicate:

(a) "That the initial load due to screwing up a bolt to make a steam-tight joint may be estimated at 16000 lb. per in. nominal dia. of bolt or $\frac{16000}{0.55}$ = 29000 lb. per sq. in. of bolt at base of thread for a 1-in. bolt, and that

(b) the intensity of stress varies, approximately, inversely as the nominal dia. of the bolt."

This shows that with bolt steel at 60000 lb. per sq. in. ultimate tensile strength we have a factor of safety of only 2 for 1-in. bolts, less than 2 for smaller bolts and a little over 2 for larger bolts, as against a factor of safety of about 16 for 12 in. extra heavy pipe. $\left(\frac{\text{Burst pressure}}{\text{Work pressure}} = \frac{3930}{250} = 16\right)$

Where compressible gaskets are used the total load on the bolts is that due to initial tension plus from 50% to 100% applied load, thus further decreasing the factor of safety.

(See Kimball & Barr's Elements of Machine Design, p. 170)

and flanges, and have recommended to the members of their society that they use it in their designs.

SCHEDULE OF STANDARD WEIGHT AND EXTRA HEAVY FLANGED FITTINGS

THE 1912 U. S. STANDARD

Adopted October 25, 1911, by a Committee of the National Association of Master Steam and Hot Water Fitters and of The American Society of Mechanical Engineers

EXPLANATORY NOTES

1 Standard or extra heavy reducing elbows carry same dimensions center to face as regular elbows of largest straight size.

2 Standard or extra heavy tees, crosses and laterals, reducing on run, carry same dimensions face to face as largest straight size.

3 If flanged fittings for lower working pressures than 125 lb. are made, they shall conform in all dimensions, except thickness of shell, to this standard, and shall have the guaranteed working pressure cast on each fitting. Flanges for these fittings must be standard dimensions.

4 Where long-turn fittings are specified, it has reference only to elbows, which are made in two center to face dimensions, to be known as " elbows " and " long-turn" elbows, the latter being used only when so specified.

5 All standard weight fittings must be guaranteed for 125 lb. and extra heavy fittings for 250 lb. working pressure, and each fitting must have some mark cast on it indicating the maker and guaranteed working steam pressure.

6 All extra heavy fittings and flanges to have a raised surface $\frac{1}{16}$ in. high inside of bolt holes for gasket.

Standard weight fittings and flanges to be plain faced.

Bolts to be $\frac{1}{8}$ in. smaller in diameter than bolt holes.

Bolt holes should straddle center lines.

7 Size of all fittings scheduled indicates inside diameter of ports. For outside diameter pipe use corresponding size of inside diameter fittings.

8 The face to face dimension of a reducer, either straight or eccentric, shall be equal to the diameter of the larger flange.

9 Square head bolts with hexagonal nuts are recommended.

10 Twin ells, double branch ells, side outlet ells, side outlet tees and four-way tees, whether straight sizes or reducing, carry same dimensions center to face and face to face as regular ells and tees.

11 Bull head tees or tees increasing on outlet will have same center to face and face to face dimensions as a straight fitting of the size of the outlet.

12 Up to and including the 4 in. size, center to face and face to face dimensions

of reducing fittings will be the same as that of a straight fitting of the larger opening. (See table for reducing fittings larger than 4 in.)

STEEL FLANGES, FITTINGS AND VALVES ARE RECOMMENDED FOR SUPERHEATED STEAM.

Committees on Standardization

William J. Baldwin, Jr. N. Loring Danforth William T. English William P. Kirk Thomas B. Cryer Edward B. Denny William H. Oakes	*National Association of Master Steam and Hot Water Fitters*
H. G. Stott John H. Sparrow Wm Schwanhausser Walter M. McFarland Albert C. Ashton	*The American Society of Mechanical Engineers*

SCHEDULE OF STANDARD WEIGHT FLANGED FITTINGS

ADOPTED OCTOBER 25, 1911, BY A COMMITTEE OF THE

NATIONAL ASSOCIATION OF MASTER STEAM AND HOT WATER FITTERS

AND OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

	Elbows	45-Deg. Elbows	Long Turn Elbows	Tees and Crosses	Single and Double Laterals or Y Branches, and Y's
1 inch					
Center to Face	3½	2	5½	3½	2 & 6*
Face to Face	....	....	....	7	8
Diameter of Flange	4	4	4	4	4
Thickness of Flange	7/16	7/16	7/16	7/16	7/16
Diameter of Bolt Circle	3	3	3	3	3
Number of Bolt Holes	4	4	4	4	4
Diameter of Bolt Holes	9/16	9/16	9/16	9/16	9/16
1¼ inch					
Center to Face	3¾	2	6	3¾	2¼&6¼*
Face to Face	....	....	....	7½	8½
Diameter of Flange	4½	4½	4½	4½	4½
Thickness of Flange	½	½	½	½	½
Diameter of Bolt Circle	3⅜	3⅜	3⅜	3⅜	3⅜
Number of Bolt Holes	4	4	4	4	4
Diameter of Bolt Holes	9/16	9/16	9/16	9/16	9/16
1½ inch					
Center to Face	4	2¼	6½	4	2⅜&6⅞*
Face to Face	....	....	....	8	9¼
Diameter of Flange	5	5	5	5	5
Thickness of Flange	9/16	9/16	9/16	9/16	9/16
Diameter of Bolt Circle	3⅞	3⅞	3⅞	3⅞	3⅞
Number of Bolt Holes	4	4	4	4	4
Diameter of Bolt Holes	⅝	⅝	⅝	⅝	⅝
2 inch					
Center to Face	4½	2½	7	4½	2½ & 8*
Face to Face	....	....	....	9	10½
Diameter of Flange	6	6	6	6	6
Thickness of Flange	⅝	⅝	⅝	⅝	⅝
Diameter of Bolt Circle	4¾	4¾	4¾	4¾	4¾
Number of Bolt Holes	4	4	4	4	4
Diameter of Bolt Holes	¾	¾	¾	¾	¾

Asterisk (*) indicates center to face dimensions of run on laterals or double laterals, each way. The smaller dimension is also the center to face dimension of a Y on the short end. All other dimensions on Y's are the same as for elbows of the same size. A reducing Y carries same dimensions as a straight size Y of the size of the largest opening in the fitting in question.

	Elbows	45-Deg. Elbows	Long Turn Elbows	Tees and Crosses	Single and Double Laterals or Y Branches, and Y's
2½ inch					
Center to Face	5	2¾	7½	5	2½&9½*
Face to Face	....	....	....	10	12
Diameter of Flange	7	7	7	7	7
Thickness of Flange	11/16	11/16	11/16	11/16	11/16
Diameter of Bolt Circle	5½	5½	5½	5½	5½
Number of Bolt Holes	4	4	4	4	4
Diameter of Bolt Holes	¾	¾	¾	¾	¾
3 inch					
Center to Face	5½	3	8	5½	3 & 10*
Face to Face	....	....	....	11	13
Diameter of Flange	7½	7½	7½	7½	7½
Thickness of Flange	¾	¾	¾	¾	¾
Diameter of Bolt Circle	6	6	6	6	6
Number of Bolt Holes	4	4	4	4	4
Diameter of Bolt Holes	¾	¾	¾	¾	¾
3½ inch					
Center to Face	6	3½	9	6	3&11½*
Face to Face	....	....	...	12	14½
Diameter of Flange	8½	8½	8½	8½	8½
Thickness of Flange	13/16	13/16	13/16	13/16	13/16
Diameter of Bolt Circle	7	7	7	7	7
Number of Bolt Holes	4	4	4	4	4
Diameter of Bolt Holes	¾	¾	¾	¾	¾
4 inch					
Center to Face	6½	4	10	6½	3 & 12*
Face to Face	....	....	....	13	15
Diameter of Flange	9	9	9	9	9
Thickness of Flange	15/16	15/16	15/16	15/16	15/16
Diameter of Bolt Circle	7½	7½	7½	7½	7½
Number of Bolt Holes	8	8	8	8	8
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞
4½ inch					
Center to Face	7	4¼	11	7	3&12½*
Center to Face of Outlet, outlets 4 in. and under	....	....	....	...	11⅞
Center to Face of Outlet, outlets 4½ in.	...	....	....	.	12½
Face to Face	...	...	...	14	15½
Diameter of Flange	9¼	9¼	9¼	9¼	9¼
Thickness of Flange	15/16	15/16	15/16	15/16	15/16
Diameter of Bolt Circle	7¾	7¾	7¾	7¾	7¾
Number of Bolt Holes	8	8	8	8	8
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞
5 inch					
Center to Face	7½	4½	12	7½	3½&13½*
Center to Face of Outlet, outlets 4 in. and under	...	....	....	....	12¼
Center to Face of Outlet, outlets 4½ in. and 5 in.	..	...	..	...	13½
Face to Face	....	...	.	15	17
Diameter of Flange	10	10	10	10	10
Thickness of Flange	15/16	15/16	15/16	15/16	15/16
Diameter of Bolt Circle	8½	8½	8½	8½	8½
Number of Bolt Holes	8	8	8	8	8
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞

	Elbows	45-Deg. Elbows	Long Turn Elbows	Tees and Crosses	Single and Double Laterals or Y Branches, and Y's
6 inch					
Center to Face	8	5	13	8	3½&14½*
Center to Face of Outlet, outlets 4 in. and under	....	....	....	....	13
Center to Face of Outlet, outlets 4½ in. to 6 in.	....	....	....	....	14½
Face to Face	....	....	....	16	18
Diameter of Flange	11	11	11	11	11
Thickness of Flange	1	1	1	1	1
Diameter of Bolt Circle	9½	9½	9½	9½	9½
Number of Bolt Holes	8	8	8	8	8
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞
7 inch					
Center to Face	8½	5½	14½	8½	4&16½*
Center to Face of Outlet, outlets 4 in. and under	....	....	....	....	13¾
Center to Face of Outlet, outlets 4½ in. to 7 in.	...	...	....	....	16½
Face to Face	....	....	....	17	20½
Diameter of Flange	12½	12½	12½	12½	12½
Thickness of Flange	1 1/16	1 1/16	1 1/16	1 1/16	1 1/16
Diameter of Bolt Circle	10¾	10¾	10¾	10¾	10¾
Number of Bolt Holes	8	8	8	8	8
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞
8 inch					
Center to Face	9	6	16	9	1½&17½*
Center to Face of Outlet, outlets 4 in. and under	....	....	....	....	14⅜
Center to Face of Outlet, outlets 4½ in. to 8 in.	....	....	....	....	17½
Face to Face	....	....	....	18	22
Diameter of Flange	13½	13½	13½	13½	13½
Thickness of Flange	1⅛	1⅛	1⅛	1⅛	1⅛
Diameter of Bolt Circle	11¾	11¾	11¾	11¾	11¾
Number of Bolt Holes	8	8	8	8	8
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞
9 inch					
Center to Face	10	6½	18	10	4½&19½*
Center to Face of Outlet, outlets 8 in. and under	....	....	....	9	17⅞
Center to Face of Outlet, outlets 9 in.	....	....	....	10	19½
Face to Face	....	....	....	20	24
Diameter of Flange	15	15	15	15	15
Thickness of Flange	1⅛	1⅛	1⅛	1⅛	1⅛
Diameter of Bolt Circle	13¼	13¼	13¼	13¼	13¼
Number of Bolt Holes	12	12	12	12	12
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞

STANDARD WEIGHT FLANGED FITTINGS—Continued

	Elbows	45-Deg. Elbows	Long Turn Elbows	Tees and Crosses	Single and Double Laterals or Y Branches, and Y's
10 inch					
Center to Face	11	7	20	11	5&20½*
Center to Face of Outlet, outlets 8 in. and under	....	....	....	10	18⅝
Center to Face of Outlet, outlets 9 in. and 10 in.	....	....	....	11	20½
Face to Face	....	....	....	22	25½
Diameter of Flange	16	16	16	16	16
Thickness of Flange	1 3/16	1 3/16	1 3/16	1 3/16	1 3/16
Diameter of Bolt Circle	14¼	14¼	14¼	14¼	14¼
Number of Bolt Holes	12	12	12	12	12
Diameter of Bolt Holes	1	1	1	1	1
12 inch					
Center to Face	12	7½	22	12	5½&24½*
Center to Face of Outlet, outlets 8 in. and under	....	....	..	11½	20
Center to Face of Outlet, outlets 9 in. to 12 in.	...	....	...	12	24½
Face to Face	....	....	..	24	30
Diameter of Flange	19	19	19	19	19
Thickness of Flange	1¼	1¼	1¼	1¼	1¼
Diameter of Bolt Circle	17	17	17	17	17
Number of Bolt Holes	12	12	12	12	12
Diameter of Bolt Holes	1	1	1	1	1
14 inch					
Center to Face	14	7½	24	14	6&27*
Center to Face of Outlet, outlets 8 in. and under	....	....	....	12½	21½
Center to Face of Outlet, outlets 9 in. to 14 in.	....	....	....	14	27
Face to Face	....	....	....	28	33
Diameter of Flange	21	21	21	21	21
Thickness of Flange	1⅜	1⅜	1⅜	1⅜	1⅜
Diameter of Bolt Circle	18¾	18¾	18¾	18¾	18¾
Number of Bolt Holes	12	12	12	12	12
Diameter of Bolt Holes	1⅛	1⅛	1⅛	1⅛	1⅛
15 inch					
Center to Face	14½	8	26	14½	6&28½*
Center to Face of Outlet, outlets 8 in. and under	....	....	....	13	22⅛
Center to Face of Outlet, outlets 9 in. to 15 in.	....	....	....	14½	28½
Face to Face	....	....	....	29	34½
Diameter of Flange	22¼	22¼	22¼	22¼	22¼
Thickness of Flange	1⅜	1⅜	1⅜	1⅜	1⅜
Diameter of Bolt Circle	20	20	20	20	20
Number of Bolt Holes	16	16	16	16	16
Diameter of Bolt Holes	1⅛	1⅛	1⅛	1⅛	1⅛

STANDARD WEIGHT FLANGED FITTINGS—Continued

	Elbows	45-Deg. Elbows	Long Turn Elbows	Tees and Crosses	Single and Double Laterals or Y Branches, and Y's
16 inch					
Center to Face	15	8	28	15	6½&30*
Center to Face of Outlet, outlets 8 in. and under	....	....	....	13½	22⅞
Center to Face of Outlet, outlets 9 in. to 16 in.	....	....	....	15	30
Face to Face	....	....	....	30	36½
Diameter of Flange	23½	23½	23½	23½	23½
Thickness of Flange	1 7/16	1 7/16	1 7/16	1 7/16	1 7/16
Diameter of Bolt Circle	21¼	21¼	21¼	21¼	21¼
Number of Bolt Holes	16	16	16	16	16
Diameter of Bolt Holes	1⅛	1⅛	1⅛	1⅛	1⅛
18 inch					
Center to Face	16½	8½	30	16½	7&32*
Center to Face of Outlet, outlets 8 in. and under	....	....	....	14½	24¼
Center to Face of Outlet, outlets 9 in. to 18 in.	....	....	....	16½	32
Face to Face	....	....	....	33	39
Diameter of Flange	25	25	25	25	25
Thickness of Flange	1 9/16	1 9/16	1 9/16	1 9/16	1 9/16
Diameter of Bolt Circle	22¾	22¾	22¾	22¾	22¾
Number of Bolt Holes	16	16	16	16	16
Diameter of Bolt Holes	1¼	1¼	1¼	1¼	1¼
20 inch					
Center to Face	18	9½	32	18	8&35*
Center to Face of Outlet, outlets 8 in. and under	....	....	....	15½	25¾
Center to Face of Outlet, outlets 9 in. to 20 in.	....	....	....	18	35
Face to Face	....	....	....	36	43
Diameter of Flange	27½	27½	27½	27½	27½
Thickness of Flange	1 11/16	1 11/16	1 11/16	1 11/16	1 11/16
Diameter of Bolt Circle	25	25	25	25	25
Number of Bolt Holes	20	20	20	20	20
Diameter of Bolt Holes	1¼	1¼	1¼	1¼	1¼
22 inch					
Center to Face	20	10	34	20	8½&37½*
Center to Face of Outlet, outlets 8 in. and under	....	....	....	16½	27⅛
Center to Face of Outlet, outlets 9 in. to 22 in.	....	....	....	20	37½
Face to Face	....	....	....	40	46
Diameter of Flange	29½	29½	29½	29½	29½
Thickness of Flange	1 13/16	1 13/16	1 13/16	1 13/16	1 13/16
Diameter of Bolt Circle	27¼	27¼	27¼	27¼	27¼
Number of Bolt Holes	20	20	20	20	20
Diameter of Bolt Holes	1¼	1¼	1¼	1¼	1¼

STANDARD WEIGHT FLANGED FITTINGS—Continued

	Elbows	45-Deg. Elbows	Long Turn Elbows	Tees and Crosses	Single and Double Laterals or Y Branches, and Y's
24 inch					
Center to Face..............	22	11	36	22	9&40½*
Center to Face of Outlet, outlets 8 in. and under........	....	....	....	17½	28½
Center to Face of Outlet, outlets 9 in. to 24 in...........	....	....	....	22	40½
Face to Face................	....	....	....	44	49½
Diameter of Flange..........	32	32	32	32	32
Thickness of Flange..........	1⅞	1⅞	1⅞	1⅞	1⅞
Diameter of Bolt Circle......	29½	29½	29½	29½	29½
Number of Bolt Holes........	20	20	20	20	20
Diameter of Bolt Holes.......	1¼	1¼	1¼	1¼	1¼
26 inch					
Center to Face..............	23	13	39	23	9½&43½*
Center to Face of Outlet, outlets 8 in. and under........	....	....	....	19½	30¾
Center to Face of Outlet, outlets 9 in. to 26 in...........	....	....	....	23	43½
Face to Face................	....	....	....	46	53
Diameter of Flange..........	34¼	34¼	34¼	34¼	34¼
Thickness of Flange..........	2	2	2	2	2
Diameter of Bolt Circle......	31¾	31¾	31¾	31¾	31¾
Number of Bolt Holes........	24	24	24	24	24
Diameter of Bolt Holes......	1⅜	1⅜	1⅜	1⅜	1⅜
28 inch					
Center to Face..............	24	14	42	24	10½&46½*
Center to Face of Outlet, outlets 8 in. and under........	....	....	....	20½	33
Center to Face of Outlet, outlets 9 in. to 28 in...........	....	....	....	24	46½
Face to Face................	....	....	....	48	57
Diameter of Flange..........	36½	36½	36½	36½	36½
Thickness of Flange..........	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16
Diameter of Bolt Circle......	34	34	34	34	34
Number of Bolt Holes........	28	28	28	28	28
Diameter of Bolt Holes......	1⅜	1⅜	1⅜	1⅜	1⅜
30 inch					
Center to Face..............	25	15	45	25	11 & 49½*
Center to Face of Outlet, outlets 8 in. and under........	....	....	....	21½	35½
Center to Face of Outlet, outlets 9 in. to 30 in..........	....	....	....	25	49½
Face to Face................	....	....	....	50	60½
Diameter of Flange..........	38¾	38¾	38¾	38¾	38¾
Thickness of Flange..........	2⅛	2⅛	2⅛	2⅛	2⅛
Diameter of Bolt Circle......	36	36	36	36	36
Number of Bolt Holes........	28	28	28	28	28
Diameter of Bolt Holes.......	1½	1½	1½	1½	1½

SCHEDULE OF EXTRA HEAVY FLANGED FITTINGS

ADOPTED OCTOBER 25, 1911, BY A COMMITTEE OF THE
NATIONAL ASSOCIATION OF MASTER STEAM AND HOT WATER FITTERS
AND
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

	Elbows	45-Deg. Elbows	Long Turn Elbows	Tees and Crosses	Single and Double Laterals or Y Branches, and Y's
1 inch					
Center to Face	4¼	2½	5½	4¼	2⅝&7⅛*
Face to Face	....	....	....	8½	9¾
Diameter of Flange	4½	4½	4½	4½	4½
Thickness of Flange	11/16	11/16	11/16	11/16	11/16
Diameter of Bolt Circle	3¼	3¼	3¼	3¼	3¼
Number of Bolt Holes	4	4	4	4	4
Diameter of Bolt Holes	⅝	⅝	⅝	⅝	⅝
1¼ inch					
Center to Face	4¼	2½	6	4¼	2⅝&7⅛*
Face to Face	....	....	....	8½	9¾
Diameter of Flange	5	5	5	5	5
Thickness of Flange	¾	¾	¾	¾	¾
Diameter of Bolt Circle	3¾	3¾	3¾	3¾	3¾
Number of Bolt Holes	4	4	4	4	4
Diameter of Bolt Holes	⅝	⅝	⅝	⅝	⅝
1½ inch					
Center to Face	4½	2¾	6½	4½	2½&8½*
Face to Face	....	....	....	9	11
Diameter of Flange	6	6	6	6	6
Thickness of Flange	13/16	13/16	13/16	13/16	13/16
Diameter of Bolt Circle	4½	4½	4½	4½	4½
Number of Bolt Holes	4	4	4	4	4
Diameter of Bolt Holes	¾	¾	¾	¾	¾
2 inch					
Center to Face	5	3	7	5	2½&9½*
Face to Face	....	....	....	10	12
Diameter of Flange	6½	6½	6½	6½	6½
Thickness of Flange	⅞	⅞	⅞	⅞	⅞
Diameter of Bolt Circle	5	5	5	5	5
Number of Bolt Holes	4	4	4	4	4
Diameter of Bolt Holes	¾	¾	¾	¾	¾
2½ inch					
Center to Face	5½	3¼	7½	5½	2½&10½*
Face to Face	....	....	....	11	13
Diameter of Flange	7½	7½	7½	7½	7½
Thickness of Flange	1	1	1	1	1
Diameter of Bolt Circle	5⅞	5⅞	5⅞	5⅞	5⅞
Number of Bolt Holes	4	4	4	4	4
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞
3 inch					
Center to Face	6	3½	8	6	3&11½*
Face to Face	....	....	....	12	14½
Diameter of Flange	8¼	8¼	8¼	8¼	8¼
Thickness of Flange	1⅛	1⅛	1⅛	1⅛	1⅛
Diameter of Bolt Circle	6⅝	6⅝	6⅝	6⅝	6⅝
Number of Bolt Holes	8	8	8	8	8
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞

Asterisk (*) indicates center to face dimensions of run on laterals or double laterals, each way. The smaller dimension is also the center to face dimension of a Y on the short end. All other dimensions on Y's are the same as for elbows of the same size. A reducing Y carries same dimensions as a straight size Y of the size of the largest opening in the fitting in question.

EXTRA HEAVY FLANGED FITTINGS—Continued

	Elbows	45-Deg. Elbows	Long Turn Elbows	Tees and Crosses	Single and Double Laterals or Y Branches, and Y's
3½ inch					
Center to Face	6½	4	9	6½	3&12½*
Face to Face	....	....	....	13	15½
Diameter of Flange	9	9	9	9	9
Thickness of Flange	1³⁄₁₆	1³⁄₁₆	1³⁄₁₆	1³⁄₁₆	1³⁄₁₆
Diameter of Bolt Circle	7¼	7¼	7¼	7¼	7¼
Number of Bolt Holes	8	8	8	8	8
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞
4 inch					
Center to Face	7	4¼	10	7	3&13½*
Face to Face	....	....	....	14	16½
Diameter of Flange	10	10	10	10	10
Thickness of Flange	1¼	1¼	1¼	1¼	1¼
Diameter of Bolt Circle	7⅞	7⅞	7⅞	7⅞	7⅞
Number of Bolt Holes	8	8	8	8	8
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞
4½ inch					
Center to Face	7½	4½	11	7½	3½&14½*
Center to Face of Outlet, outlets 4 in. and under	....	....	....	....	13⅝
Center to Face of Outlet, outlets 4½ in.	....	....	....	....	14½
Face to Face	....	....	....	15	18
Diameter of Flange	10½	10½	10½	10½	10½
Thickness of Flange	1⁵⁄₁₆	1⁵⁄₁₆	1⁶⁄₁₆	1⁵⁄₁₆	1⁵⁄₁₆
Diameter of Bolt Circle	8½	8½	8½	8½	8½
Number of Bolt Holes	8	8	8	8	8
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞
5 inch					
Center to Face	8	5	12	8	3½&16*
Center to Face of Outlet, outlets 4 in. and under	....	....	....	....	14
Center to Face of Outlet, outlets 4½ in. and 5 in.	....	....	....	....	16
Face to Face	....	....	....	16	19½
Diameter of Flange	11	11	11	11	11
Thickness of Flange	1⅜	1⅜	1⅜	1⅜	1⅜
Diameter of Bolt Circle	9¼	9¼	9¼	9¼	9¼
Number of Bolt Holes	8	8	8	8	8
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞
6 inch					
Center to Face	9	5½	13	9	4&17½*
Center to Face of Outlet, outlets 4 in. and under	....	....	...	....	14⅝
Center to Face of Outlet, outlets 4½ in. to 6 in.	....	...	...	....	17½
Face to Face	....	....	....	18	21½
Diameter of Flange	12½	12½	12½	12½	12½
Thickness of Flange	1⁷⁄₁₆	1⁷⁄₁₆	1⁷⁄₁₆	1⁷⁄₁₆	1⁷⁄₁₆
Diameter of Bolt Circle	10⅝	10⅝	10⅝	10⅝	10⅝
Number of Bolt Holes	12	12	12	12	12
Diameter of Bolt Holes	⅞	⅞	⅞	⅞	⅞

EXTRA HEAVY FLANGED FITTINGS—Continued

	Elbows	45-Deg. Elbows	Long Turn Elbows	Tees and Crosses	Single and Double Laterals or Y Branches, and Y's
7 inch					
Center to Face	9½	5¾	14½	9½	4½&19*
Center to Face of Outlet, outlets 4 in. and under	....	....	....	....	15⅜
Center to Face of Outlet, outlets 4½ in. to 7 in.	....	....	....	....	19
Face to Face	....	....	....	19	23½
Diameter of Flange	14	14	14	14	14
Thickness of Flange	1½	1½	1½	1½	1½
Diameter of Bolt Circle	11⅞	11⅞	11⅞	11⅞	11⅞
Number of Bolt Holes	12	12	12	12	12
Diameter of Bolt Holes	1	1	1	1	1
8 inch					
Center to Face	10½	6	16	10½	5&20½*
Center to Face of Outlet, outlets 4 in. and under	....	....	....	....	16
Center to Face of Outlet, outlets 4½ in. to 8 in.	....	....	....	....	20½
Face to Face	....	....	....	21	25½
Diameter of Flange	15	15	15	15	15
Thickness of Flange	1⅝	1⅝	1⅝	1⅝	1⅝
Diameter of Bolt Circle	13	13	13	13	13
Number of Bolt Holes	12	12	12	12	12
Diameter of Bolt Holes	1	1	1	1	1
9 inch					
Center to Face	11	6½	18	11	5&22¾*
Center to Face of Outlet, outlets 8 in. and under	....	....	....	10½	20⅞
Center to Face of Outlet, outlets 9 in.	....	....	....	11	22¾
Face to Face	....	....	....	22	27¾
Diameter of Flange	16¾	16¾	16¾	16¾	16¾
Thickness of Flange	1¾	1¾	1¾	1¾	1¾
Diameter of Bolt Circle	14	14	14	14	14
Number of Bolt Holes	12	12	12	12	12
Diameter of Bolt Holes	1⅛	1⅛	1⅛	1⅛	1⅛
10 inch					
Center to Face	12	7	20	12	5½&25¼*
Center to Face of Outlet, outlets 8 in. and under	....	....	....	11	21⅝
Center to Face of Outlet, outlets 9 in. and 10 in.	....	....	....	12	25¼
Face to Face	....	....	....	24	30¾
Diameter of Flange	18¼	18¼	18¼	18¼	18¼
Thickness of Flange	1⅞	1⅞	1⅞	1⅞	1⅞
Diameter of Bolt Circle	15¾	15¾	15¾	15¾	15¾
Number of Bolt Holes	16	16	16	16	16
Diameter of Bolt Holes	1⅛	1⅛	1⅛	1⅛	1⅛

	Elbows	45-Deg. Elbows	Long Turn Elbows	Tees and Crosses	Single and Double Laterals or Y Branches, and Y's
12 inch					
Center to Face	13½	8	22	13½	6&27¾*
Center to Face of Outlet, outlets 8 in. and under	....	....	....	12	23
Center to Face of Outlet, outlets 9 in. to 12 in.	....	....	....	13½	27¾
Face to Face	....	....	....	27	33¾
Diameter of Flange	20¾	20¾	20¾	20¾	20¾
Thickness of Flange	2	2	2	2	2
Diameter of Bolt Circle	17¾	17¾	17¾	17¾	17¾
Number of Bolt Holes	16	16	16	16	16
Diameter of Bolt Holes	1¼	1¼	1¼	1¼	1¼
14 inch					
Center to Face	15	9½	24	15	6½&31¼*
Center to Face of Outlet, outlets 8 in. and under	....	....		13	24⅜
Center to Face of Outlet, outlets 9 in. to 14 in.	....	....		15	31¼
Face to Face	....	....	....	30	37¾
Diameter of Flange	23½	23½	23½	23½	23½
Thickness of Flange	2⅛	2⅛	2⅛	2⅛	2⅛
Diameter of Bolt Circle	20¼	20¼	20¼	20¼	20¼
Number of Bolt Holes	20	20	20	20	20
Diameter of Bolt Holes	1⅜	1⅜	1⅜	1⅜	1⅜
15 inch					
Center to Face	15½	10	26	15½	6½&33¼*
Center to Face of Outlet, outlets 8 in. and under	....	....	..	13½	25⅛
Center to Face of Outlet, outlets 9 in. to 15 in.	....	....	....	15½	33¼
Face to Face	....	....	....	31	39¾
Diameter of Flange	25	25	25	25	25
Thickness of Flange	2 3/16	2 3/16	2 3/16	2 3/16	2 3/16
Diameter of Bolt Circle	21½	21½	21½	21½	21½
Number of Bolt Holes	20	20	20	20	20
Diameter of Bolt Holes	1⅜	1⅜	1⅜	1⅜	1⅜
16 inch					
Center to Face	16½	10½	28	16½	7½&34½*
Center to Face of Outlet, outlets 8 in. and under	....	...	....	14	25¾
Center to Face of Outlet, outlets 9 in. to 16 in.	....	....		16½	34½
Face to Face	....	....		33	42
Diameter of Flange	26	26	26	26	26
Thickness of Flange	2¼	2¼	2¼	2¼	2¼
Diameter of Bolt Circle	22½	22½	22½	22½	22½
Number of Bolt Holes	20	20	20	20	20
Diameter of Bolt Holes	1½	1½	1½	1½	1½

EXTRA HEAVY FLANGED FITTINGS—Continued

	Elbows	45-Deg. Elbows	Long Turn Elbows	Tees and Crosses	Single and Double Laterals or Y Branches, and Y's
18 inch					
Center to Face	17¾	11	30	17¾	8&37¾*
Center to Face of Outlet, outlets 8 in. and under	....	...	....	15	27⅛
Center to Face of Outlet outlets 9 in. to 18 in.	..	.	..	17¾	37¾
Face to Face	....	....	....	35½	45¾
Diameter of Flange	28½	28½	28½	28½	28½
Thickness of Flange	2⅜	2⅜	2⅜	2⅜	2⅜
Diameter of Bolt Circle	24¾	24¾	24¾	24¾	24¾
Number of Bolt Holes	24	24	24	24	24
Diameter of Bolt Holes	1½	1½	1½	1½	1½
20 inch					
Center to Face	19¼	11½	32	19¼	8½&40¾*
Center to Face of Outlet, outlets 8 in. and under	....	....	...	16	28⅝
Center to Face of Outlet, outlets 9 in. to 20 in.	....	....	....	19¼	40¾
Face to Face	....	....	....	38½	49¼
Diameter of Flange	31	31	31	31	31
Thickness of Flange	2½	2½	2½	2½	2½
Diameter of Bolt Circle	27	27	27	27	27
Number of Bolt Holes	24	24	24	24	24
Diameter of Bolt Holes	1⅝	1⅝	1⅝	1⅝	1⅝
22 inch					
Center to Face	20½	12	34	20½	9½&43¾*
Center to Face of Outlet, outlets 8 in. and under	....	....	....	17	30
Center to Face of Outlet outlets 9 in. to 22 in.	....	....	....	20½	43¾
Face to Face	....	....	....	41	53¼
Diameter of Flange	33	33	33	33	33
Thickness of Flange	2⅝	2⅝	2⅝	2⅝	2⅝
Diameter of Bolt Circle	29¼	29¼	29¼	29¼	29¼
Number of Bolt Holes	28	28	28	28	28
Diameter of Bolt Holes	1⅝	1⅝	1⅝	1⅝	1⅝
24 inch					
Center to Face	22½	13	36	22½	10&47½*
Center to Face of Outlet, outlets 8 in. and under	....	....	....	18	31½
Center to Face of Outlet, outlets 9 in. to 24 in.	....	....	....	22½	47½
Face to Face	....	....	....	45	57½
Diameter of Flange	36	36	36	36	36
Thickness of Flange	2¾	2¾	2¾	2¾	2¾
Diameter of Bolt Circle	32	32	32	32	32
Number of Bolt Holes	28	28	28	28	28
Diameter of Bolt Holes	1¾	1¾	1¾	1¾	1¾

SCHEDULE OF STANDARD FLANGES

For Steam Pressures up to 125 lb. per sq. in.
adopted october 25, 1911, by a committee of the
national association of master steam and hot water fitters
and of
the american society of mechanical engineers

All dimensions are in inches

Size of Pipe	Diameter of Flange	Thickness of Flange	Diameter of Bolt Circle	Number of Bolts	Size of Bolts	Diameter of Bolt Holes
1	4	7/16	3	4	7/16	9/16
1 1/4	4 1/2	1/2	3 3/8	4	7/16	9/16
1 1/2	5	9/16	3 7/8	4	1/2	5/8
2	6	5/8	4 3/4	4	5/8	3/4
2 1/2	7	11/16	5 1/2	4	5/8	3/4
3	7 1/2	3/4	6	4	5/8	3/4
3 1/2	8 1/2	13/16	7	4	5/8	3/4
4	9	15/16	7 1/2	8	3/4	7/8
4 1/2	9 1/4	15/16	7 3/4	8	3/4	7/8
5	10	15/16	8 1/2	8	3/4	7/8
6	11	1	9 1/2	8	3/4	7/8
7	12 1/2	1 1/16	10 3/4	8	3/4	7/8
8	13 1/2	1 1/8	11 3/4	8	3/4	7/8
9	15	1 1/8	13 1/4	12	3/4	7/8
10	16	1 3/16	14 1/4	12	7/8	1
12	19	1 1/4	17	12	7/8	1
14 O.D.	21	1 3/8	18 3/4	12	1	1 1/8
15 O.D.	22 1/4	1 3/8	20	16	1	1 1/8
16 O.D.	23 1/2	1 7/16	21 1/4	16	1	1 1/8
18 O.D.	25	1 9/16	22 3/4	16	1 1/8	1 1/4
20 O.D.	27 1/2	1 11/16	25	20	1 1/8	1 1/4
22 O.D.	29 1/2	1 13/16	27 1/4	20	1 1/8	1 1/4
24 O.D.	32	1 7/8	29 1/2	20	1 1/8	1 1/4
26 O.D.	34 1/4	2	31 3/4	24	1 1/4	1 3/8
28 O.D.	36 1/2	2 1/16	34	28	1 1/4	1 3/8
30 O.D.	38 3/4	2 1/8	36	28	1 3/8	1 1/2

Bolt holes should straddle center lines.

Flanges should be plain faced.

SCHEDULE OF EXTRA HEAVY FLANGES FOR EXTRA HEAVY FITTINGS AND VALVES

For Steam Pressures from 125 to 250 lb. per sq. in.
adopted october 25, 1911, by a committee of the
national association of master steam and hot water fitters
and of
the american society of mechanical engineers
All dimensions are in inches

Size of Pipe	Diameter of Flange	Thickness of Flange	Diameter of Bolt Circle	Number of Bolts	Size of Bolts	Diameter of Bolt Holes
1	4½	¹¹⁄₁₆	3¼	4	½	⅝
1¼	5	¾	3¾	4	½	⅝
1½	6	¹³⁄₁₆	4½	4	⅝	¾
2	6½	⅞	5	4	⅝	¾
2½	7½	1	5⅞	4	¾	⅞
3	8¼	1⅛	6⅝	8	¾	⅞
3½	9	1³⁄₁₆	7¼	8	¾	⅞
4	10	1¼	7⅞	8	¾	⅞
4½	10½	1⁵⁄₁₆	8½	8	¾	⅞
5	11	1⅜	9¼	8	¾	⅞
6	12½	1⁷⁄₁₆	10⅝	12	¾	⅞
7	14	1½	11⅞	12	⅞	1
8	15	1⅝	13	12	⅞	1
9	16¾	1¾	14	12	1	1⅛
10	18¼	1⅞	15¾	16	1	1⅛
12	20¾	2	17¾	16	1⅛	1¼
14 O.D.	23½	2⅛	20¼	20	1¼	1⅜
15 O.D.	25	2³⁄₁₆	21½	20	1¼	1⅜
16 O.D.	26	2¼	22½	20	1⅜	1½
18 O.D.	28½	2⅜	24¾	24	1⅜	1½
20 O.D.	31	2½	27	24	1½	1⅝
22 O.D.	33	2⅝	29¼	28	1½	1⅝
24 O.D.	36	2¾	32	28	1⅝	1¾

Bolt Holes should straddle center lines.

Flanges should have ¹⁄₁₆ inch raised face for gaskets.

Square Head Bolts with hexagonal nuts are recommended.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The semi-annual banquet of the Armour Institute Student Branch was held on December 20, and was attended by the faculty of the Mechanical Department and by the Junior and Senior Students.

At a professional session on January 11, A. W. Semerak gave a talk on Steel Belting, illustrated by lantern slides. He stated that steel belts have been developed to the greatest extent in Germany where they are used for many different kinds of drives, to replace leather belts and rope drives. Examples of successful installations of steel belts were quoted and many details of construction described.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

At a meeting of the Mechanical Engineering Society of the Massachusetts Institute of Technology, on December 19, J. F. Hoxie, Mem. Am. Soc. M. E., spoke on the Cause of the Growth of Fungii in Wood, showing by the aid of numerous slides the different kinds of infected wood and of fungii at different stages of development, and why they grow more rapidly in one piece of wood than in another.

On December 21, B. R. T. Collins, Mem. Am. Soc. M. E., gave a talk on The Economizing of Power Plants. He spoke particularly of his own experience, stating the cause of complaint and his method of examination and procedure, with the results obtained.

OHIO STATE UNIVERSITY

G. H. Mueller, chief engineer of the Jeffrey Manufacturing Company, addressed a meeting of the Ohio State University Student Branch on December 18, upon the subject of Power Plant Machinery, dealing especially with the history of improvements in this field and with the various types of conveyors used. He predicted a great future for concrete in connection with power plant construction. The discussion was participated in by E. A. Hitchcock, F. E. Sanborn, H. Seitz, H. Belt, and W. Assel.

The branch was visited on January 4 by Calvin W. Rice, Secretary of the Society, who met with a cordial reception at the hands of the students. He spoke principally of the advantages to the students of affiliation with the Society.

POLYTECHNIC INSTITUTE OF BROOKLYN

At a meeting of the branch on December 9, Prof. Wm. T. Magruder, Mem. Am. Soc. M. E., spoke upon Progress in Engineering during 1911. On January 6 the members were addressed by Wm. T. Donnelly, Mem. Am. Soc. M. E., on Floating Dry Docks.

STEVENS INSTITUTE OF TECHNOLOGY

Three lectures by prominent engineers were delivered before the Stevens Engineering Society in the month of December. These were: The Comparative Economics of Coal and Water Gas, by Arthur H. Elliott, on December 6; Vapors for Heat Engines, by Wm. D. Ennis, Mem. Am. Soc. M. E., on December 14; and The Progress of Mechanical Engineering in 1911, by Wm. T. Magruder, Mem. Am. Soc. M. E., on December 19.

On December 9 the Branch inspected the power house of the Hudson & Manhattan Railroad in Jersey City, through the courtesy of its officials.

The branch was the guest of the Polytechnic Institute student branch on January 6, when a lecture by Wm. T. Donnelly, Mem. Am. Soc. M. E., was presented. The question of consolidation of these two branches for their mutual strengthening is under consideration.

On January 9 Roy C. Whitall (Student, 1912) presented a paper on The Automatic Telephone, which was discussed by O. C. Roesen, G. L. Clouser, A. E. Bauhan, and Messrs. Langlotz and Stern.

On January 11 Charles Kirchhoff, Mem. Am. Soc. M. E., President of the American Institute of Mining Engineers, delivered a lecture on Factors in the Development of the Iron Industry.

UNIVERSITY OF CINCINNATI

Calvin W. Rice, Secretary of the Society, addressed the University of Cincinnati Student Branch on the benefits of the membership in the Society on January 4. He called attention to the advantages afforded by a student section and emphasized the importance of joining the Society after graduation. Addresses were also made by E. F. Du Brul, Assoc. Am. Soc. M. E., A. L. De Leeuw, Mem. Am. Soc. M. E., Dean Herman Schneider of the College of Engineering, and F. A. Stanley, of The American Machinist.

UNIVERSITY OF KANSAS

In addition to the regular monthly meetings, the University of Kansas Student Branch held its third annual meeting December 14, 1911, characterized by the elaborate preparations in the way of entertainment and the carefully arranged program which give to this organization its unique distinction. The program was as follows: Address of Welcome, F. O. Marvin; The Action of Reciprocating Pump Valves, C. I. Corp, Jun. Am. Soc. M. E.; The Technical School Engineer, Louis Bendit, Mem. Am. Soc. M. E.; Shop Management, B. W. Benedict. Lunch was then served, after which an opportunity was afforded to inspect the new Santa Fé dynamometer car. This was followed by a demonstration of the automatic screw machine by the National Acme Machine Company, Fowler Shops, and a conclusion of the professional program consisting of papers on Drilling Gas Wells, W. M. Welch; The Manufacture of Iron and Steel, W. A. Whitaker, and an address, The Santa Fé Dynamometer Car, H. B. McFarland, Mem. Am. Soc. M. E. A banquet was held in the evening at which Prof. P. E. Walker, Mem. Am. Soc. M. E., presided as toastmaster.

UNIVERSITY OF KENTUCKY

The University of Kentucky Student Branch was addressed by Calvin W. Rice, Secretary of the Society, on January 5, upon the work of the Society and the advantages which it offers to student branches. He was enthusiastically received by the membership.

UNIVERSITY OF MISSOURI

The Student Branch at the University of Missouri enjoyed a visit from Calvin W. Rice, Secretary of the Society, on January 8, and a large audience of faculty members and engineering students listened to a brief address by him on the work of the Society with particular reference to the student branches.

NECROLOGY

CARYL D. HASKINS

Caryl D. Haskins was born at Waltham, Mass., May 22, 1867, and obtained his early education in the public schools of Philadelphia and Dedham, Pa. In 1879 he went to England, where he attended the Allison Towers and Roslyndale schools, devoted to the preparation of boys for military and engineering work, and later studied under the London University tuition system for a year. In 1887 he entered the employ of Haskins, Davis & Company, specializing in gas-engine work. Six months later he entered the shops of S. Z. Ferranti, where he was connected with the early work at the Old Grosvenor and Deptford stations. Returning to the United States in 1889, he was employed as designing draftsman by the Thomson Electric Welding Company, Lynn, Mass., but was soon transferred to the Thomson-Houston Electric Company as assistant foreman of the meter department. Shortly afterwards he was given charge of the company's outside meter interests. When the General Electric Company was formed, Mr. Haskins was put in charge of the meter interests of the consolidated company. In 1893 he was also given charge of the company's instrument department and in 1900 of the switchboard department.

While Mr. Haskins is best known as a meter expert, he was also an inventor in other lines, including the subjects of steel refining, meters, transformers, switches, circuit-breakers, time relays, etc. Perhaps his most important as well as most ingenious invention was an auto-dirigible torpedo, for which he refused several offers from foreign powers.

Mr. Haskins also found time for literary work. He was the author of a book on Transformers and of a work of fiction entitled, For the Queen in South Africa. He also lectured frequently at army and navy institutes. He had made a special study of electricity as applied to offense, and particularly to defense, in time of war and was considered an authority on this subject, and frequently acted in an advisory capacity to the Government in matters of this nature.

Mr. Haskins was a member of the American Institute of Electrical

Engineers and the National Electric Light Association and was an associate member of the Military Service Institute and the United States Naval Academy. He died November 18, 1911.

WARREN S. JOHNSON

Warren S. Johnson was born in Leicester, Vt., November 6, 1847, and died December 5, 1911. At an early age the family moved to Waukesha, Wis., where he attended school and learned the printer's trade. At seventeen years of age he became foreman in a newspaper office at Durand, Wis., at the same time attending high school. He taught school in Menominee for a number of years and then became county superintendent of schools. In 1876 he was appointed professor of mathematics, sciences and drawing at the state normal school at Whitewater, Wis. Here he maintained a private laboratory where he experimented with storage batteries and where he conceived the idea of automatic temperature regulation. In 1883 he resigned his professorship and formed a partnership with William Plankinton of Milwaukee, where he developed the Johnson system of temperature regulation, now used all over the world. In 1885 the partnership became a corporation known as the Johnson Electric Service Company, the name being changed later to the Johnson Service Company.

The temperature regulator was not Mr. Johnson's only invention. Others were a brass foundry furnace, gasolene gas machine, pneumatic clock and time system, wireless telegraph system, automobile parts and various devices used in connection with the business in which he was engaged. The huge pneumatic clock at the St. Louis Exposition in 1904 was made by Mr. Johnson. He also constructed the city hall clock in Philadelphia, the largest in the world, and the city hall clock in Milwaukee which has the largest bell in the world.

Mr. Johnson was a member of the Franklin Institute, the American Institute of Electrical Engineers and the American Society of Heating and Ventilating Engineers.

EDGAR W. MIX

Edgar W. Mix was born at Columbus, Ohio, February 4, 1867, and in 1888 was graduated from the Ohio State University with the degree of B. S. The two years following were spent in the employ of the Thomson-Houston Electric Company, Lynn, Mass., in general shop work and practice and in the development of the Thomson recording watt meter. In 1890 he took this meter to Paris where it was awarded first prize in the meter contest. The following five years were devoted to general engineering, designing and installing various electric railway and lighting plants in France and Russia. In 1895 he became chief engineer of the Société des Etablissements Postel-Vinay, Paris, which concern was then controlled and has since been absorbed by the Thomson-Houston Electric Company. In this capacity Mr. Mix played an important part in the development of all the electrical machinery which the company have been building since he joined them, as well as steam turbines and modern extraction machinery for collieries. He left the Thomson-Houston Company in October 1911, to take up the European branch of the General Motors Export Company of America.

Mr. Mix was a member of both the Aero Club of France and the Aero Club of America, and represented both countries in the international balloon race from Zurich on October 5, 1909, in which he was the only American contestant. He died suddenly November 12, 1911.

HUGH S. MORRISON

Hugh S. Morrison was born in Petersburg, Va., July 7, 1877, and died at Saranac Lake, N. Y., November 24, 1911. He was educated at the high schools and for two years was a student at the Virginia Mechanics Institute, Richmond. He obtained his shop experience at the Richmond Iron Works, where he was foreman of the boiler shop, and at the Petersburg Iron Works, Roanoke Rapids, N. C., being in charge of the outside construction work. In July 1898 he entered the drawing-room of the Richmond Locomotive Works and later became assistant to the superintendent in charge of the layout and construction of the new Smith boiler, machine and special shops and track system in the yard. He opened an office of his own in 1901, and was for a short time associated with Mr. Kinderwater. During this period he designed the machinery and layout and the heating and ventilating systems for the Baughman Stationery Company, as well as the layout of the entire building. In 1903 he became a member of the firm of Myers, Finney & Morrison, designing and constructing special machinery, and was responsible for the drawings and specifications for the Keely cotton compress for that company, Chester, S. C. Mr. Morrison organized the Morrison Machinery & Supply Company of Richmond, Va., in 1905, with which he was actively connected until his death.

THOMAS F. SALTER

Thomas F. Salter was born in Prattsville, N. Y., March 31, 1875, and after his graduation from the Syracuse, N. Y., high school, learned his trade in the machine shops of the Syracuse Specialty & Manufacturing Company, and through correspondence schools and private tutors. The several years following he was employed by the General Electric Company, Schenectady, N. Y., and by the Western Electric Company, New York City. From 1902 to 1906 he was assistant to the executive engineer of the C. W. Hunt Company, West New Brighton, N. Y., being instrumental in designing machinery for a number of coal-hoisting installations for the United States Government, various railroads, and other users of such apparatus, and was considered by them an engineer and designer of unusual ability. He then entered the employ of the North Penn Iron Company, Philadelphia, Pa., as chief engineer and manager of the shop. While here he designed and constructed a special 20-ton hand-traveling crane for the Cambria Steel Company, intended for operation in a building of semicircular form. He was also responsible for three 5-ton 3-motor electric traveling cranes for the Bureau of Supplies and Accounts, Navy Department, which were erected at the Charleston Navy Yard. At the time of his death, October 25, 1911, he was manager of sales and engineering with the Standard Roller Bearing Company, Philadelphia, Pa.

Mr. Salter was a member of the New York Railroad Club, the Society of Automobile Engineers, the Interurban and Street Railway Association and the Sales Managers Association.

DESIGN AND MECHANICAL FEATURES OF THE CALIFORNIA GOLD DREDGE

By Robert E. Cranston

ABSTRACT OF PAPER

Detailed information in regard to all conditions is requisite in order to properly design a gold dredge. The first California dredge, built in 1897–1898, was patterned after the New Zealand type, and the present California type dredge is a combination of this type and several others.

The buckets are made with cast steel base, pressed steel hood and manganese steel lip. The lower tumbler is a 6-sided steel casting with renewable wearing plates over which the buckets pass. They then travel up a structural steel ladder on rollers and over a 6-sided upper tumbler which is driven by a chain of cast-steel gears. The buckets dump their material into a hopper which discharges into a shaking or revolving screen. The fine material goes through onto gold-saving tables and the coarse material is stacked aft of the dredge by means of a belt conveyor. The dredge is held in place by steel spuds and moved by means of side lines running to a motor-driven winch. The digging ladder is raised by means of a separate winch driven by the digging motor. Water is furnished under pressure by motor-driven centrifugal pumps. The hull is built of Douglas fir and should be designed last.

For rough estimating the cost of a modern California type dredge can be figured at about $180 per ton.

THE DESIGN AND MECHANICAL FEATURES OF THE CALIFORNIA GOLD DREDGE

By Robert E. Cranston, Sacramento, Cal.

Member of the Society

This paper deals only with that branch of gold dredging which comes directly within the province of mechanical engineering, and the designs described are those commonly used in California. No attempt is made to cover the whole field, and the author has recorded only his personal observations of the more important mechanical features.

2 In designing a gold dredge the first essentials to be determined are the quantity of material to be handled and the depth to which it will be necessary to dig. To a lesser degree, the size and quantity of boulders, quantity of clay, nature and contour of bed rock, contour of the surface, whether the dredge is to be operated in a river or in an inland pond, how high above the water line it will be necessary to maintain the bank, the nature and consistency of the gravel, distance from a railroad or other cheap transportation, costs of lumber, labor, electric power, supplies, etc., condition of wagon roads, distance and transportation facilities to a first class machine shop, climate, distance to nearest public power line, and possibilities of developing electric power on or near the property, are important. If electric power is not available, then the costs of the various fuels for generating steam or running gas engines must be considered, and if the dredge is to be operated inland, how much water is available, and any other data peculiar to the property.

3 All the above information is requisite for the proper design of a dredge to do the most efficient work. A designer should insist on a full knowledge of all the conditions, otherwise his product is likely to be more or less unsuited to the work it has to do.

4 Beginning with the capacity required, the dimensions of the bucket bases, pins, lips, etc., and the horsepower of the digging

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motor are determined. The depth of ground determines the length of ladder, which is modified by the height to which it is desired to elevate in order to wash and dispose of the gravel properly. The screen pumps and stacker are designed according to the quantity and quality of coarse material and the height to which it is to be stacked. The other machinery is designed to suit the local conditions, and the hull is planned to support the machinery properly, its dimensions varying greatly from the small capacity shallow diggers, to the 16-ft. dredges excavating 60 or 70 ft. below water line.

5 The mechanical equipment of the California gold dredge as it is today has in it much to be desired in the way of correct dimensions and the relative strengths of its component parts. Many of these parts should be made stronger, likewise there is much waste material which could just as well be done away with. Notwithstanding these admitted faults the California gold dredge has during the last few years shown vast improvement over the earlier attempts, and with all its frailties has many good points in its make-up which might be profitably studied by engineers called upon to design similar pieces of machinery.

6 The first successful gold dredges in California were patterned after the New Zealand type. A brief description of one of these, built in 1897 and 1898, will not perhaps be out of place (Fig. 1).

7 The hull was built of wood of a rectangular cross-section, having an opening or well extending along the center line part way back from the bow. Near the after end of this well was built an elevated framed structure or main gantry which served to support one end of the digging ladder, the other end being suspended by wire rope blocks from a head frame or "bow gantry" spanning the well. This ladder was a plate girder upon which were mounted rollers to carry the bucket line. The bucket line was composed of alternate links and buckets pinned together to form an endless chain. The buckets passed over a four-sided flanged tumbler keyed to a shaft and driven by a spur gear mounted on the main gantry. At the lower end of the ladder another tumbler served as an idler. In going over the upper tumbler the buckets dumped into a hopper leading into an inclined revolving screen with $\frac{3}{8}$-in. to $\frac{5}{8}$-in. perforations. A spray pipe ran lengthways through the screen, throwing jets of water upon the gravel and washing the finer particles and gold through the screen holes upon gold-saving tables. These tables were covered with cocoanut matting held in place by expanded metal and were arranged so as first to distribute the fine material over a considerable area and

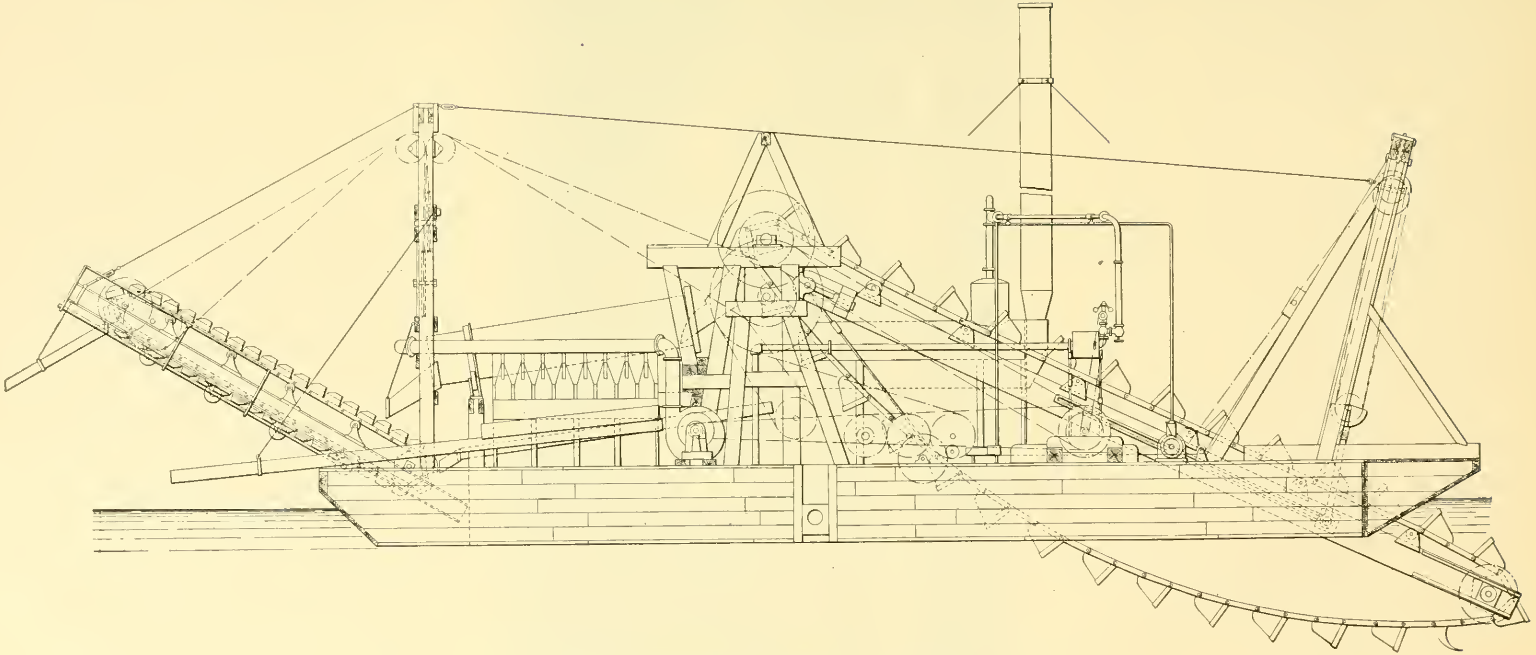


Fig. 1 First Successful California Dredge, 1897–1898

then discharge it at the stern; the oversize went to a bucket elevator and was stacked some distance aft of the dredge. The dredge was held up to its work by a head line which could be reeled in by means of a drum on the dredge. Side movement was secured by lines, two at the bow and two at the stern, each running to a separate drum. The motive power for these dredges was steam, which was soon replaced by electricity.

8 Three years before this type of dredge was introduced in California, one of the type known as the double-lift was built near Bannock, Mont. The main gantry was much lower than in the New Zealand type. A revolving screen was used, but the holes were much larger, so that rocks 4 in. to 6 in. in diameter would pass through. The oversize was dumped at the side of the dredge, and the undersize allowed to collect in a sump from whence it was elevated by means of a centrifugal pump into a sluice running aft from near the throat of the well. At the stern was a pivot connection with another sluice mounted on an auxiliary scow. This scow could be moved from side to side, one end of its sluice being pivoted at the stern of the dredge and the other moving in the arc of a circle, thus distributing the gravel over a considerable area. Instead of a head line, spuds

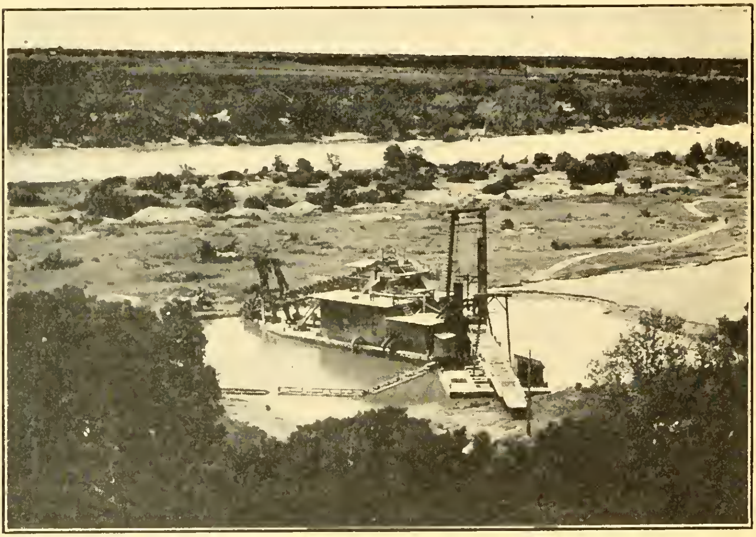


Fig. 2 Single-Lift California Gold Dredge, 1900

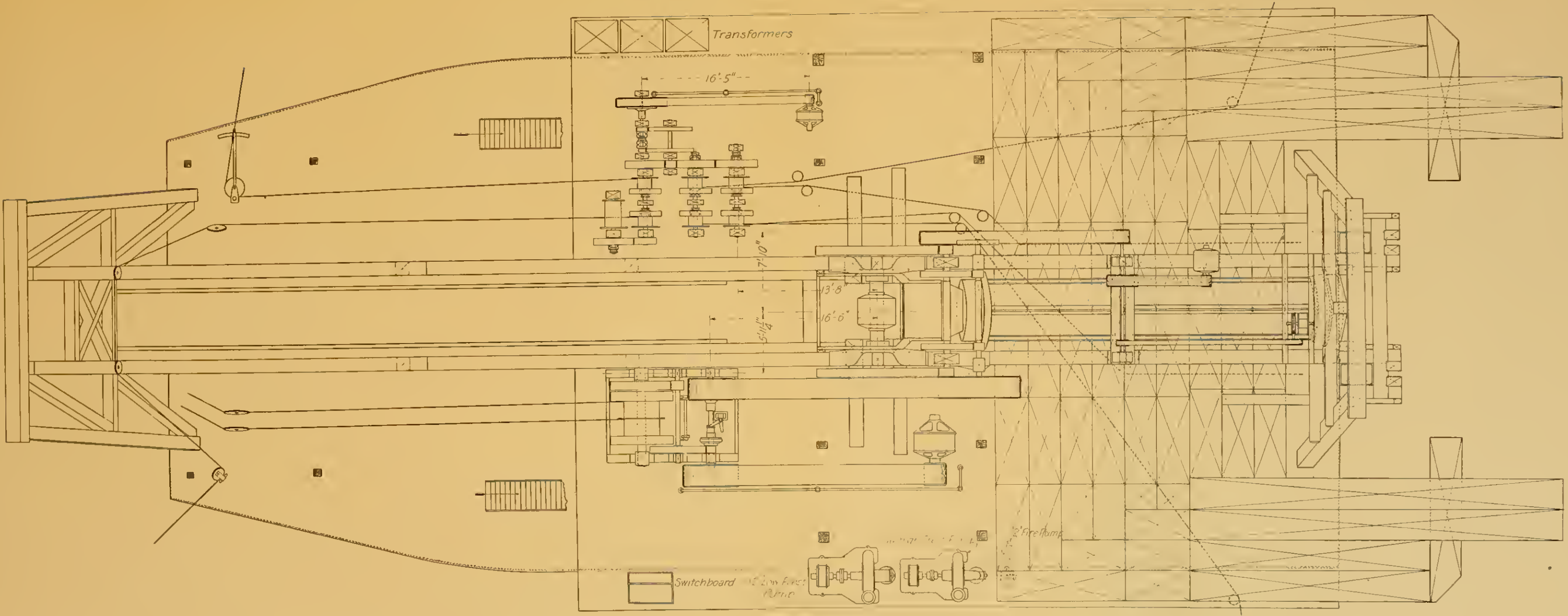
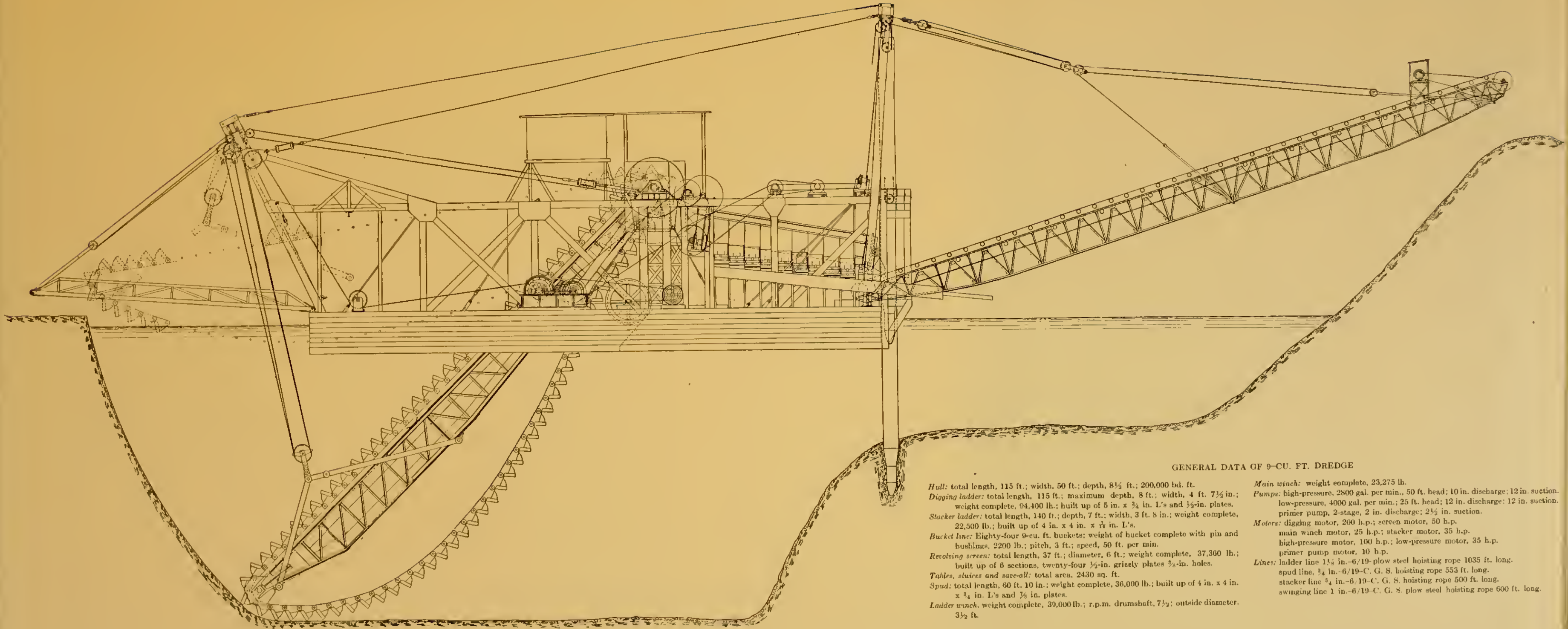


Fig. 4 Plan, 9-Cu. Ft. Dredge



GENERAL DATA OF 9–CU. FT. DREDGE

Hull: total length, 115 ft.; width, 50 ft.; depth, 8½ ft.; 200,000 bd. ft.

Digging ladder: total length, 115 ft.; maximum depth, 8 ft.; width, 4 ft. 7½ in.; weight complete, 94,400 lb.; built up of 5 in. x ¾ in. L's and ½-in. plates.

Stacker ladder: total length, 140 ft.; depth, 7 ft.; width, 3 ft. 8 in.; weight complete, 22,500 lb.; built up of 4 in. x 4 in. x 7/16 in. L's.

Bucket line: Eighty-four 9-cu. ft. buckets; weight of bucket complete with pin and bushings, 2200 lb.; pitch, 3 ft.; speed, 50 ft. per min.

Revolving screen: total length, 37 ft.; diameter, 6 ft.; weight complete, 37,360 lb.; built up of 6 sections, twenty-four ½-in. grizzly plates ⅜-in. holes.

Tables, sluices and save-all: total area, 2430 sq. ft.

Spud: total length, 60 ft. 10 in.; weight complete, 36,000 lb.; built up of 4 in. x 4 in. x ¾ in. L's and ⅞ in. plates.

Ladder winch. weight complete, 39,000 lb.; r.p.m. drumshaft, 7½; outside diameter, 3½ ft.

Main winch: weight complete, 23,275 lb.

Pumps: high-pressure, 2800 gal. per min., 50 ft. head; 10 in. discharge; 12 in. suction.
low-pressure, 4000 gal. per min.; 25 ft. head; 12 in. discharge: 12 in. suction.
primer pump, 2-stage, 2 in. discharge; 2½ in. suction.

Motors: digging motor, 200 h.p.; screen motor, 50 h.p.
main winch motor, 25 h.p.; stacker motor, 35 h.p.
high-pressure motor, 100 h.p.; low-pressure motor, 35 h.p.
primer pump motor, 10 h.p.

Lines: ladder line 1⅛ in.–6/19–plow steel hoisting rope 1035 ft. long.
spud line, ¾ in.–6/19–C. G. S. hoisting rope 553 ft. long.
stacker line ¾ in.–6/19–C. G. S. hoisting rope 500 ft. long.
swinging line 1 in.–6/19–C. G. S. plow steel hoisting rope 600 ft. long.

FIG. 5 ELEVATION, 9-CU. FT. DREDGE

were used to hold the dredge up to its work, the end of the digging ladder moving in the arc of a circle with the spud as its center.

9 About this time several dipper dredges were built, but although some were more or less successful they did not prove to be as efficient as the endless chain type and were soon abandoned.

10 In 1899 a double-lift dredge was built at Oroville, and soon after a similar dredge was built on the American River, the latter, however, being of the single-lift type (Fig. 2), using close-connected buckets (every link in the chain being a bucket instead of links and buckets alternating) with spuds, no stacker, but having its main gantry high, the buckets dumping into a revolving screen with large holes. This screen was raised high enough so that the finer material fell directly into a fore-and-aft sluice; the oversize dumped into stone shoots discharging on both sides of the dredge.

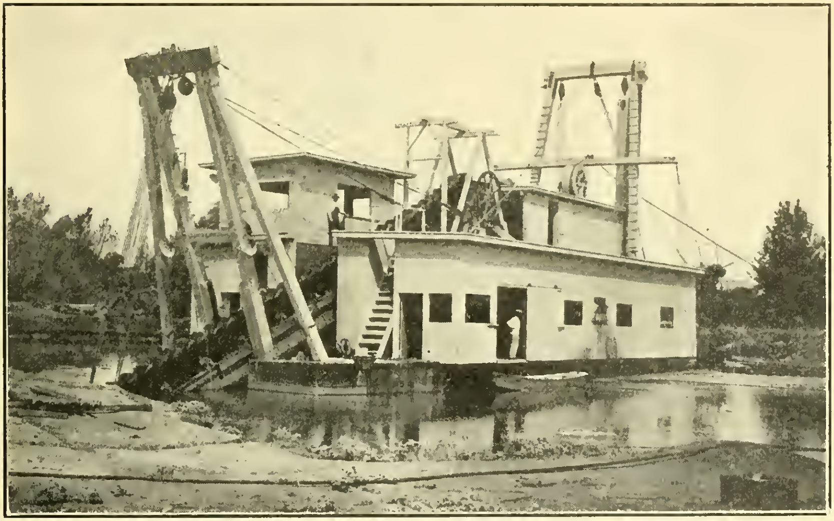


Fig. 3 First California Type Gold Dredge, 1901

11 A judicious combination of the best features of the New Zealand and the double and single-lift types described above, together with several new ideas not used in any of the earlier dredges, resulted in a dredge being built some time in 1901, near Oroville, Cal. (Fig. 3), equipped with a shaking instead of a revolving screen, the holes in which were small, the fine material going to gold-saving tables as in the New Zealand type, but with Hungarian riffles replac-

ing the cocoanut matting and expanded metal. The oversize was stacked at the stern by means of a belt conveyor instead of a bucket

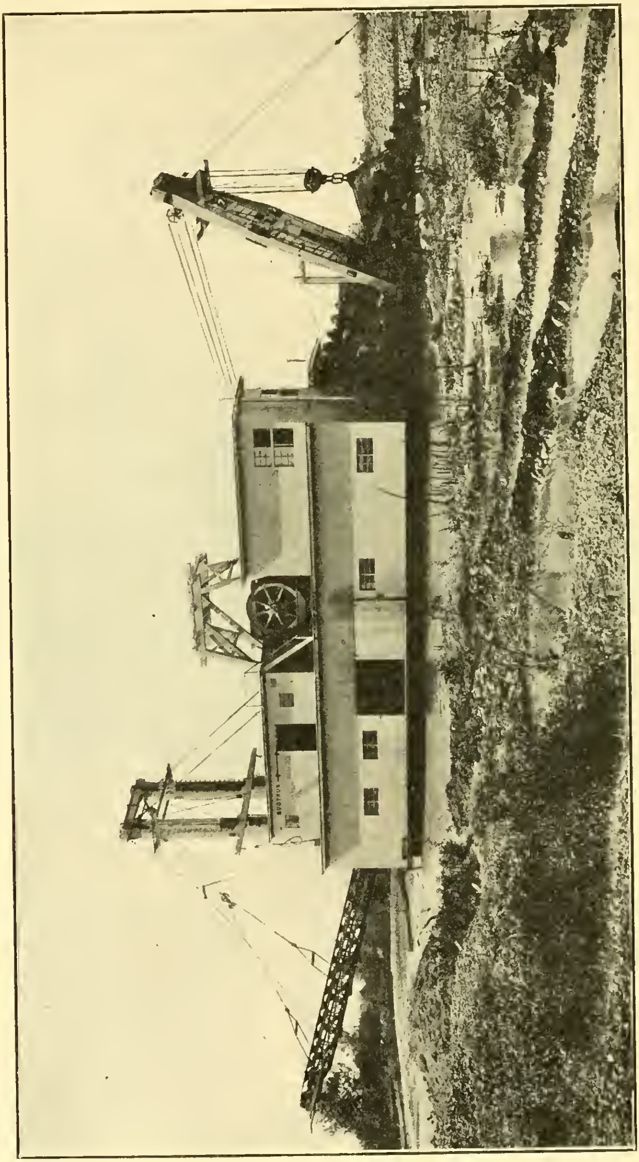


Fig. 6 Modern 5-Cu. Ft. Gold Dredge, 1907

elevator. Spuds and close-connected buckets were used as in the single-lift type. This general arrangement became known as the

California type, and with its later modifications is the one to receive the most attention in this paper, and unless otherwise stated the descriptions are for this type of dredge. A plan and elevation of this type are shown in Figs. 4 and 5.

12 The original New Zealand type slightly modified is still sometimes used for the smaller, shallower and richer areas, where it is said to do very good work. It is cheaper to build and under certain conditions may prove a better investment than the more expensive California type.

13 The earlier dredges used buckets holding 3 cu. ft., then the 5-ft. size became numerous (Fig. 6), and later the 7, 8 and 9-ft. sizes (Fig. 7) were much used. Many went back to the revolving screen, noticeably in localities where much clay existed. In 1905 a 13½-ft. dredge was built near Folsom, Cal. (Fig. 8), and since that time several with 13½ to 16-ft. buckets have been put in operation (Fig. 9).

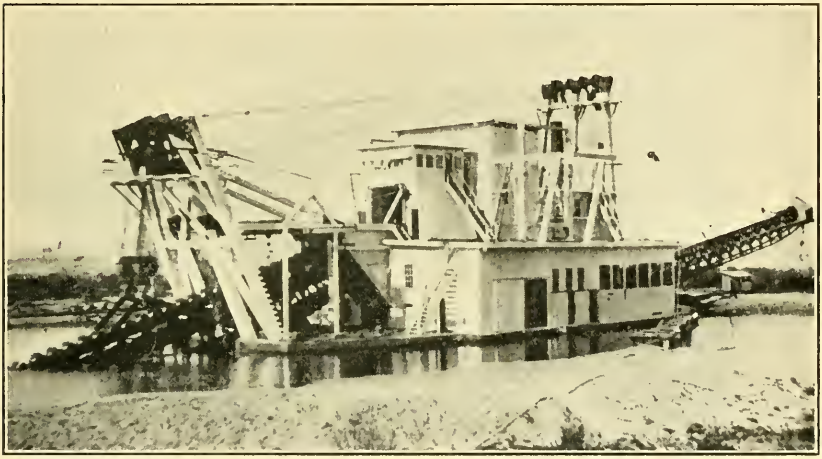


Fig 7 Modern 9-Cu. Ft. Gold Dredge, 1911

14 Having gained a general idea of the development of this type of gold dredge, its different component parts will be taken up in detail.

BUCKET

15 The bucket proper is made up of base, hood and lip (Fig. 10).

16 *Base.* The base is made of cast steel, many grades being used. It should be hard so as to stand wear, tough so as to stand the strain of digging, and should not be too expensive, since it has constantly to be replaced when worn or broken. All dredge costs

are figured on a basis of cents per cubic yard of gravel handled, so that the first cost is not vital so long as it will handle the requisite number of cubic yards before giving out.

17 The most common form of base has one hub or back eye fitting between the two front eyes of the bucket behind it. Some use two back and three front eyes. The advantage of the three-eye bucket is that a smaller diameter pin may be used, there being four planes of shear instead of two; the disadvantage is that the cost of machining is greater and there seems to be a tendency to crack these buckets between the two back eyes, owing probably to a prying action under hard digging conditions, particularly after the pins are partly worn.

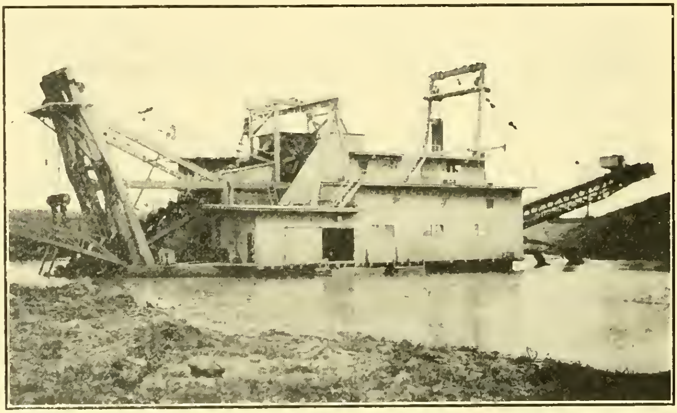


FIG. 8 MODERN $13\frac{1}{2}$-CU. FT. GOLD DREDGE, 1905

18 Besides the ordinary high-carbon open-hearth steel, chrome nickel and manganese steels are used. One essential is that the bucket casting should be thoroughly annealed before it is machined. It is my opinion that many breaks in bucket bases have been caused solely by improper annealing.

19 A template having long guiding bushed holes is useful in drilling for the hood so that the rivet holes will be accurately spaced both inside and out. This is essential in order that there may be no lost time in making replacements. In machining the base the holes in the eyes should be very carefully bored so as to be exactly parallel with the hole in the hub. In order to do this the bucket may be fitted with its bushing, a shaft put through the hub, the bucket

brought tightly against it, and then the eyes bored parallel to this shaft.

20 *Hood.* The bucket hood is made either of pressed steel or cast steel. There are also buckets used which have the hood cast as an integral part of the base. The pressed steel hoods are made in either one or three pieces. The thickness depends on the size of bucket and the nature of the digging, and varies from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. It is sometimes reinforced at the back where the greatest wear occurs. The cast-steel hoods are usually made about $\frac{3}{4}$ in. thick, have a stiffening rib running up the middle, and sometimes shoulders for the lip to rest on and a shoulder for the base to fit into.

21 The advantages of pressed over cast-steel hoods are their cheapness, lightness, and ease of repair if bent or broken. A disadvantage is that the strength cannot always be put where wanted except at extra cost.

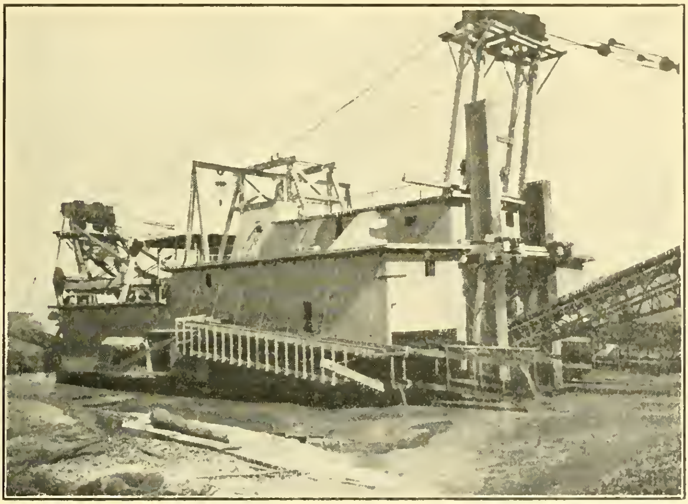


Fig. 9 Modern 16-Cu. Ft. Gold Dredge, 1911

22 A standard drilled base may be used as a template for drilling the hood. The author considers the one-piece preferable to the three-piece hood because (*a*) it will stay water tight; and (*b*) there are fewer rivets to work loose and replace. The disadvantage is the difficulty of pressing a single piece into the proper shape, making the cost slightly greater than if three pieces were used.

23 *Lip.* Bucket lips are now nearly all made of cast manganese

steel. At one time the author used a very hard high-carbon nickel-steel forging, its only advantage being that it could be shaped on the ground to fit several different hoods and bases which it was desired to use up. A record was kept of about 100 of these lips and it was found that for cost and life they were very close to the manganese steel. For use in out of the way places and in emergencies they do very well. Their greatest disadvantage is that they cannot be readily forged into the more intricate shapes now commonly used.

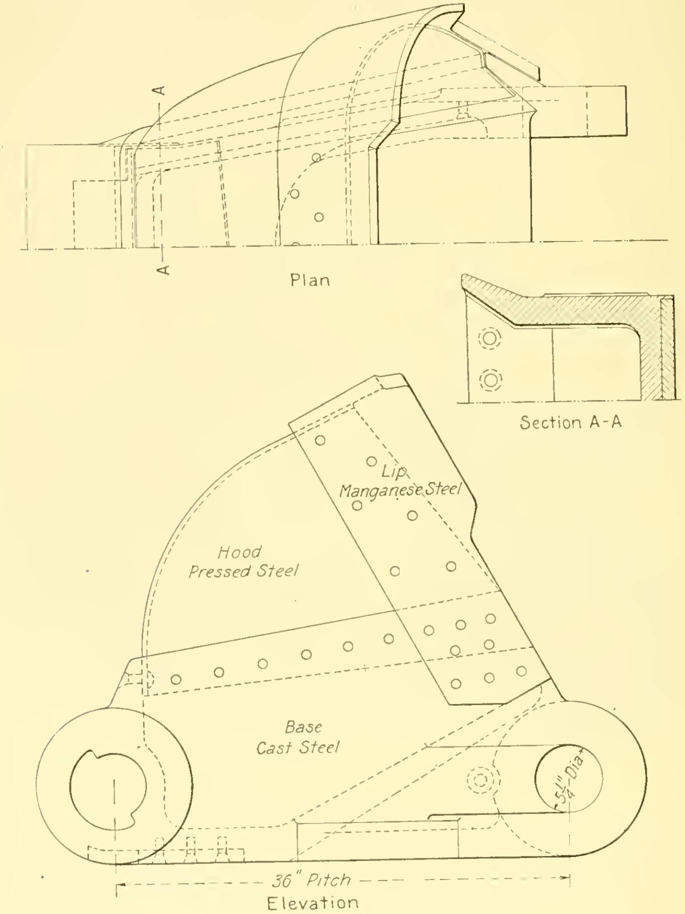


Fig. 10 9-Cu. Ft. Bucket

24 The lips in use vary considerably in design according to the nature of the ground and the fancy or judgment of the designer.

In the first place, a lip must be made sturdy enough to perform its work without bending or breaking, even up to the time it is ready to be replaced. If it is bent or broken before this time, damage is done the hood, with the resultant extra cost of repairing the hood as well as replacing the lip. The thickness of the lip is determined by the above conditions, but its width is a matter of judgment, since if made too wide the capacity of the bucket is materially reduced by the time it is worn out; if too narrow, it must be replaced often and a large loss made in each replacement both in time and unused metal.

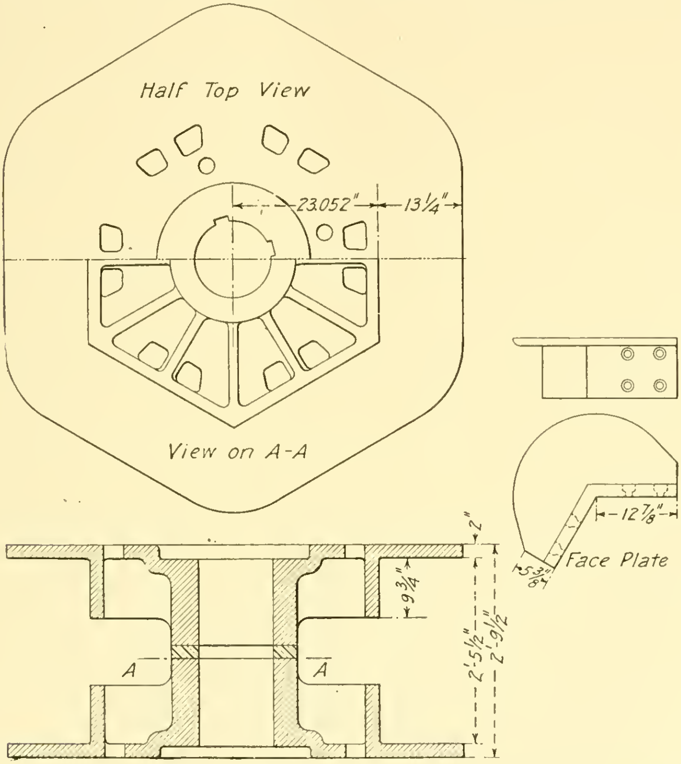


Fig. 11 Lower Tumbler for 9-Cu. Ft. Dredge, showing Wearing Plate

25 Some engineers prefer a highly arched digging face, others a rather flat face with sharply rounded corners. Those favoring the arched face contend with good reason that it is a stronger shape, and those favoring the flat face and rounded corners think that this shape is a better digger. The shape of the digging edge is another matter in which designers differ; some make it perfectly straight, others

prefer corner extensions at the points where the wear indicates most of the digging is done. The author is in favor of the corner extensions, since he believes they dig better and the lip is more completely worn out when it is ready to be replaced.

26 The fewer rivets used the smaller will be the cost of re-assembling, but care must be taken to have enough rivets to do the work without shearing or pulling out. On many of the lip designs a shoulder is cast so that the hood edge fits against it, thus taking much of the strain off the rivets.

27 *Pin.* There have been many attempts to improve the design of bucket pins, those ordinarily used being rather expensive to make. It is a round shaft with a flat lug or "L" at one end. The L fits into a slot machined in the bucket base and prevents the pin turning in the eyes. Dowel pins, keys, squared and slotted ends, tee shapes and many other devices have been tried, but so far as the author is aware none of them has proved as satisfactory as the old L design.

28 The pins are made of various kinds of steel, the object being to use a very hard material which is also tough and not too expensive. A high-carbon steel, low in sulphur and phosphorus, forged, machined, and then oil tempered, is most common. Various forms of nickel, chrome and manganese steel are also used, but so far have not become general practice.

29 *Bushing.* The bushings are made in pairs, half round, and fit a recess in the bucket hub, placed at such an angle that the wear will be evenly distributed. They should be a snug fit, but ¼ in. to ½ in. short on the ends to allow for the flow of the metal. In using manganese steel this tendency to flow must always be taken into consideration and suitable provision made for it in the dimensions.

30 *Insert Plates.* During the last few years manganese steel insert plates have come into general use in order to protect the bottom of the bucket base near the hub, at which point excessive wear occurs on account of the slip on the upper tumbler. Often buckets are found to be worn out at this point but perfectly good everywhere else. The manganese plates are of such a shape that after they are put in place and the softer steel of the base peened over the edges they retain their position without other means of fastening.

LOWER TUMBLER

31 At the lower end of the digging ladder the buckets pass over a 6-sided flanged tumbler (Fig. 11) which revolves between forks at-

tached to the digging ladder. It is cast of open-hearth steel. Wearing plates are used to protect the faces and the flanges. The detail of design varies on different dredges. Some use a tumbler having curved extensions at the corners of the flanges, others have the corners rounded but not extended, and still others use a circular flange. The extended corners require less metal but are likely to be broken off, and the circular flange may interfere with the digging. The design in which a side view will show a hexagonal shape with rounded corners is strong and cannot well interfere with the digging. The height of flange is another point of difference and varies from 6 in. to 13 in. at the corners. It must be made high enough to keep the buckets from running off, but if too high may interfere with the digging. It is also expensive.

32 The slope or flare of the flange varies from 0 to 1 in 10. It is claimed by some that if the sides are made too straight that the buckets are likely to run off and if the flare is too great the eyes of the buckets will wear thin at the bottom. I do not know that any standard of flare has been adopted, but I am inclined to the belief that a straight or nearly straight flange is best, all things considered.

33 *Wearing Plates.* The flanges and tumbler faces are protected by wearing plates (Fig. 11) made of some hard steel, nickel, chrome and manganese all being used. So far as wearing qualities are concerned the manganese steel gives the best result, but this material is so hard that it cannot be machined and it is difficult to make the plates fit the tumbler accurately; also, since the rivet holes have to be cored they are likely to be a bad fit. Besides these disadvantages the manganese steel plates are very destructive to the bucket line and it is better to wear out tumbler plates than buckets. Several tumblers have recently been made with a manganese steel disc set into a recess at each corner and held in place by peening over the edges in a manner similar to the bucket insert plates described above. This method is said to have given very good results. Some use separate plates for protecting faces and flanges, while others have the wearing plates made so as to protect both faces and flanges. The advantage of the last method is that the plates are very strong and not likely to break or work loose.

34 *Shaft.* The lower tumbler shaft is usually made of nickel steel, either oil tempered, annealed, or both, and may be hollow bored or solid. It should be very securely keyed to the tumbler, and the author has found that four taper keys, two at each side, 90 or 120 deg. apart, have given the best results. Provision should be made for

driving the keys out from the inside and the tumbler should be either shrunk or pressed on.

LADDER ROLLER

35 The ladder rollers (Fig. 12) serve to support the buckets on their way from the lower to the upper tumbler. Cast iron was formerly used, but now cast steel, either high carbon, chrome or manganese, is most in favor. Very hard chilled white iron cast around a soft core has given very good results; also manganese steel made in the same way has proved even more efficient so far as wear is concerned. The writer's objection to the manganese roller is that after considerable use the soft core, if made thin, is likely to become loose, and if made thick the difference in expansion of the two metals will cause the outside shell to crack.

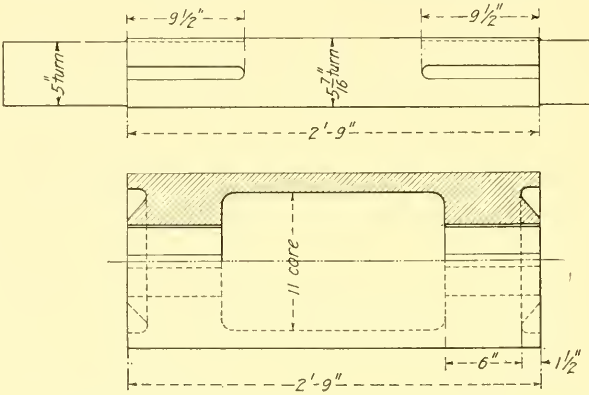


Fig. 12 Ladder Roller for 9-Cu. Ft. Dredge

36 A high-carbon or chrome-steel casting makes a good roller, and can be made just soft enough to machine; it will then wear well and need not have a soft iron core. Particularly good results have been secured by the author with chrome-steel rollers made in this way.

37 *Shaft.* There has always been trouble in keeping shafts tight in the rollers. The writer uses two taper keys at each end, 90 deg. apart, the same plan as for the lower tumbler shaft. This method of fastening has proved perfectly satisfactory.

UPPER TUMBLER

38 There have been many forms of upper tumbler tried, but now

the common practice is to use a 6-sided plain casting, onto which is bolted a set of heavy cushion plates with guides cast on the sides (Fig. 13).

39 *Cushion Plates.* These plates are made to lap over the corners and fit into transverse slots in the tumbler casting. This is done to prevent them from becoming loose, as was the case before this design was perfected. They are made of cast steel, either high carbon, chrome, nickel, or manganese. The cushion plates are bolted to the main tumbler casting by means of large bolts $1\frac{1}{2}$ or 2 in. in diameter with square countersunk heads on the outside (Fig. 14).

40 *Wearing Plates.* Wearing plates are used on the cushion plates, both for the faces and the guide flanges on the sides. These plates may be made of any material desired, but the same objection to manganese exists on the upper as the lower tumbler. The author uses plates forged from worn-out bucket pins and then gives them an oil temper. These have given good results, but care should be taken not to temper them too hard, since they then become brittle and will give poor service. The wearing plates are riveted with countersunk rivets to the cushion plates. Riveting is better than bolting for this purpose.

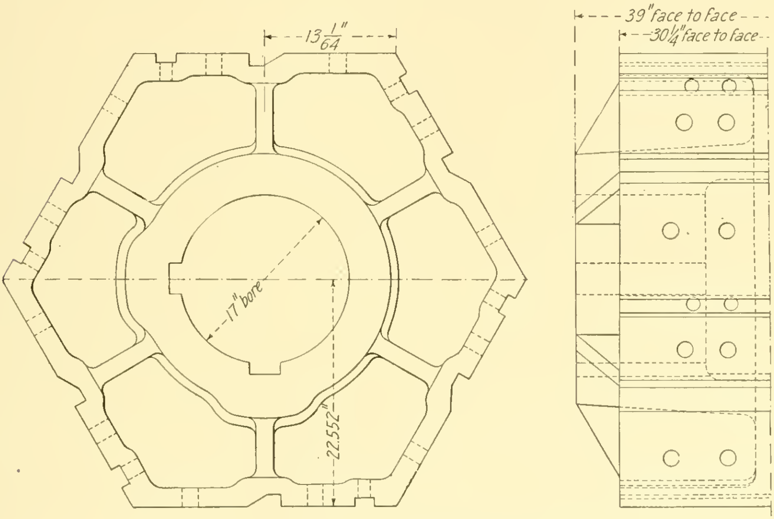


FIG. 13 UPPER TUMBLER FOR 9-CU. FT. DREDGE

41 *Shaft.* It is imperative that the upper tumbler shaft should be of ample strength and be made of excellent material since it has

to bear the brunt of the digging. A factor of safety of not less than 10 is recommended, and it would do no harm to have it even higher. It is customary to use a material of high tensile strength, since if made of low tensile strength material the shaft will have to be so large that it will interfere with the design of the upper tumbler which it carries. Nickel steel, hollow bored, oil tempered and annealed shafts are much used, having a tensile strength of 90,000 lb., elastic limit 60,000, elongation 22 per cent, contraction 50 per cent. Excellent results have also been obtained with Krupp crucible steel shafts, hollow bored, oil tempered and annealed, having a tensile strength of 80,000 lb., elastic limit, 43,000, elongation 22 per cent, contraction 45 per cent. Lately the author has used a nickel steel solid shaft which has been thoroughly annealed but not oil tempered. This has given excellent results and is inexpensive. The physical properties are as follows: Tensile strength, 80,000, elastic limit 50,000, elongation 25 per cent, contraction 45 per cent. A shaft of soft iron or steel, having a low tensile strength, but great toughness, such as Lloyds' test steel, would be the ideal shaft for this purpose were it not for the necessity of making them so large that there is no

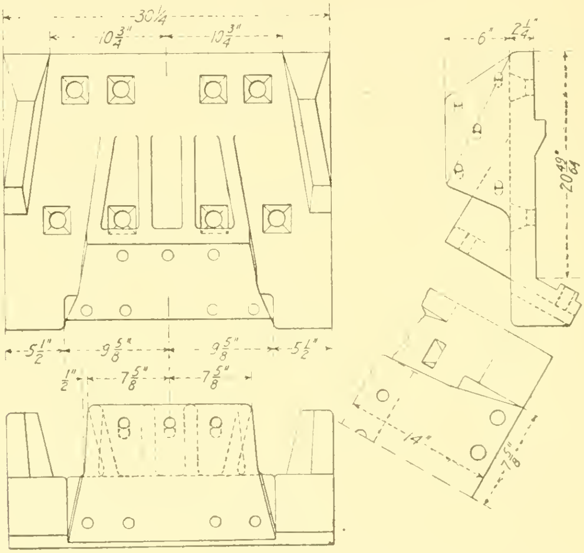


FIG. 14 CUSHION PLATES FOR UPPER TUMBLER, 9-CU. FT. DREDGE

room left to fasten the cushion plates to the upper tumbler. By using a 7 or 8-sided tumbler this difficulty could be overcome.

DIGGING LADDER

42 The design of the digging ladder varies with the depth and nature of the ground to be handled. It is either a plate girder or a lattice girder or truss (Fig. 15).

43 The plate girder type is the most common and in the writer's opinion the best. A little weight may be saved by using the lattice type, and although it may be as strong as a plate girder, there is in the lattice type more danger of rivets working loose, causing ultimate collapse.

44 Ample space should be allowed under the ladder rollers, otherwise the spill from the buckets will collect and prevent the rollers turning. The ladders are made in several sections so that they may be more easily transported. Where the splices occur great care should be taken to make the joints of ample strength. The author has seen several digging ladders fail and in nearly every case the failure occurred at one of the splices. In figuring the strains in a digging ladder it should be considered not only as a beam supported at two or three points, but also as a column. Where a single line is used for side swinging, the strains must also be figured for side as well as vertical stress.

45 *Lower Forks.* At the lower end of the ladder cast-steel forks are riveted to the structural portion of the ladder. These forks are made differently by various designers, but their duty in all cases is to carry the lower tumbler bearings and give a space for the lower tumbler to revolve in. These forks should have great lateral strength since there is a tendency to spread under the severe digging conditions. The writer has found it of advantage to make the inside edges of these forks fit very closely to the outside of the tumbler, since if a large space is left rocks lodge and grind out both the tumbler and the forks. In his last design he has put in replaceable manganese steel liners on the inside of the forks and hopes that it will prevent much of the wear on tumbler flanges.

46 *Lower Tumbler Bearings.* There are several designs of lower tumbler bearings used. In the most common the lower portion of the forks are made to form one-half of the bearings and to this the other half is bolted. In this design a replaceable cast-iron bushing is made to fit inside the main casting, often of the self-aligning type. A design similar to that of the locomotive connecting-rod end, which

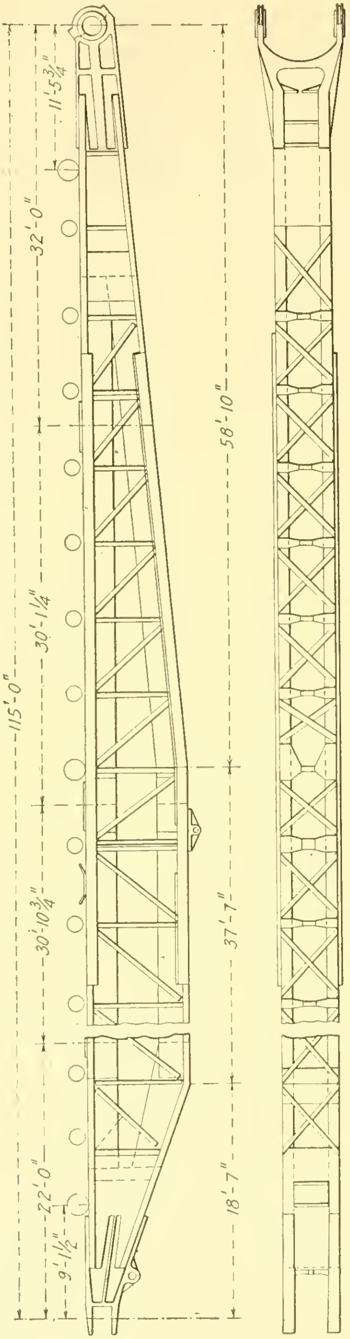


FIG. 15 DIGGING LADDER FOR 9-CU. FT. DREDGE

is fastened and adjusted by means of taper keys, has been used by the author. The bearing is made of cast iron in two halves and slides between the upper and lower extensions of the forks. Square holes are machined through these extensions to take the keys. The half bearings are interchangeable and can be used for the upper or lower half and for either side. This style of bearing has been found very satisfactory, since it is cheap and easily replaceable.

47 Many attempts have been made to use protective devices for keeping grit out of the bearings, rubber, felt, brass and iron rings having been tried. The rubber and felt have been entirely discarded. Some still use bronze or iron protective rings, but they are all more bother and cause more delays than they are worth. A hole through which grease may be introduced is provided at an easily accessible place on the bearings. The grease is introduced by means of a grease gun with a screw-operated piston.

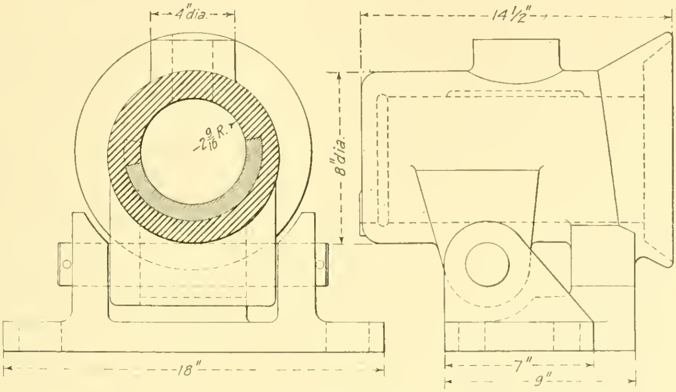


FIG. 16 LADDER ROLLER BEARING FOR 9-CU. FT. DREDGE

48 The writer uses a lower tumbler shaft with shallow flanges turned at either end. These flanges fit into recesses on the outside of the tumbler bearings, thus preventing the ladder forks from spreading. Where hollow shafts were used it was common practice at one time to put a rod lengthwise through the shaft, a nut at either end preventing the forks from springing apart. With the modern practice of making the lower forks extremely massive there is little danger of springing and precautions need not be taken in this direction.

49 *Roller Bearings.* Spaced along the digging ladder at regular intervals are the roller bearings supported in chairs by pins which

allow movement in a plane at right angles to the length of the ladder (Fig. 16). The first bearings used were fixed rigidly and much trouble was experienced by breaking roller shafts, probably caused by movement in the ladder truss. I think it likely, with the heavier ladder construction now in vogue and the larger-sized roller shafts, that the fixed bearing would give little trouble; but even so, the present common design is better since the bearing may be very quickly and easily removed, and this is a desirable feature in any part of a dredge.

50 The roller bearings are made with half-round bushings similar to those used in the bucket hubs. Cast iron, manganese steel and bronze are used for this purpose. Cast-iron roller bearings are being replaced by cast-steel. Where a self-adjusting bearing is used it should be supported near the middle and be of ample length, otherwise it will tend to tip down and wear out unevenly and rapidly.

51 *Catch-all Pan.* In some of the dredges a pan is provided below the rollers which conveys the slop-over of the buckets to the lower end of the ladder where it will be picked up again. This is a very good idea, but care should be taken to make it at least 12 in. below the rollers and in small, easily replaceable sections. If not deep enough it is likely to be a source of much annoyance by filling up and stopping the rollers, or if made in long unprotected sections it will wear out and require much work and loss of time in replacing.

52 *Suspension.* The lower end of the ladder is supported at either one or two points, the single suspension being used for the shorter ladders and the two-point suspension for the longer ones. Several different designs are in use, the most common being a double set of blocks, one on each side, attached to heavy forged rods or bars connecting with the ladder. Heavy chains, forged or cast links and pin links are also used. Another type has a single set of blocks attached to a cross-piece, the connection to the ladder being made from each of its ends. The attachment to the ladder is usually made by means of a cross-shaft or pin running through bearings fastened to the under side of the ladder.

53 *Upper Forks.* The upper end of the digging ladder is pivoted either on the tumbler shaft-bearing support or on a separate mounting entirely detached from the bucket drive. By employing the first method the tumbler shaft may be used as a center and the relative position of the bucket line and upper tumbler will remain constant for all depths of digging. In the second method the pull on the bucket line will be at different angles according to the position of the ladder. The first method, therefore, has a decided advantage, but

it also possesses the disadvantage of preventing the easy removal of the upper tumbler and shaft, is more expensive, and in case of accident to the ladder the bucket drive may be involved through the tumbler shaft-bearing support. Massive cast-steel forks are used when the ladder is pivoted on the tumbler-bearing supports, and they should extend well down the structural part of the ladder in order to give ample space for riveting.

54 *Chafing Beams.* Along the sides of the ladder wooden chafing beams are bolted, the outer faces of which are protected by steel plates. The author prefers beams put at both top and bottom of the ladder so that they will steady it when digging hard. The beams on the ladder rub against similar ones on the sides of the well. Those in the well are put either at right angles to the ladder at intervals, or one may be placed on each side of the well parallel to the deck and on the streak above water line. If this form of chafing beam is used both the ladder and the well beams should have beveled timbers fitted above them so that rocks will not lodge and cause trouble when the ladder is raised or lowered. The disadvantage of placing the chafing beams at right angles to the ladder is that in case anything catches on one of them near the bottom and tears off a plate it is very difficult to repair, while if the beams are entirely above the water line they are easily accessible. The only disadvantage of placing them in this way is that the distance from the contact point of ladder and beam to the ladder's end is greater by the draft of the hull, and in case of side strain the bending moment is greater. Where a shore sheave is used and the end of the swinging line is attached to the lower end of the ladder there is very little side strain, and in this case the horizontal wearing plates are best, in the writer's opinion. Where a single swinging line is used, running directly to the shore, considerable side strain is exerted on the ladder, and the chafing beams at right angles to the ladder are preferable. Some designers provide rollers for the sides of the ladder, which serve the same purpose as the chafing beams.

BUCKET DRIVE

55 The buckets are driven by a chain of gears mounted on the main gantry. The use of a chain or shaft drive from the lower deck has now been entirely abandoned in California practice. Some dredges drive direct from the digging motor to the pulley shaft on the main gantry. Others use a countershaft on the main deck, from which also is driven the ladder hoist. Neither type has any great

advantage over the other, and if properly designed either method will give satisfactory results.

56 The upper tumbler may be driven by a gear at one end of the tumbler shaft, or one at each end, with a double set of intermediate pinions, gears, and pulley-shaft pinions. The single drive is of course cheaper and simpler, but experience has shown that after many years of service the single drive is inclined to get out of line, even when very solidly built. The writer very much favors the double drive and would advise its use.

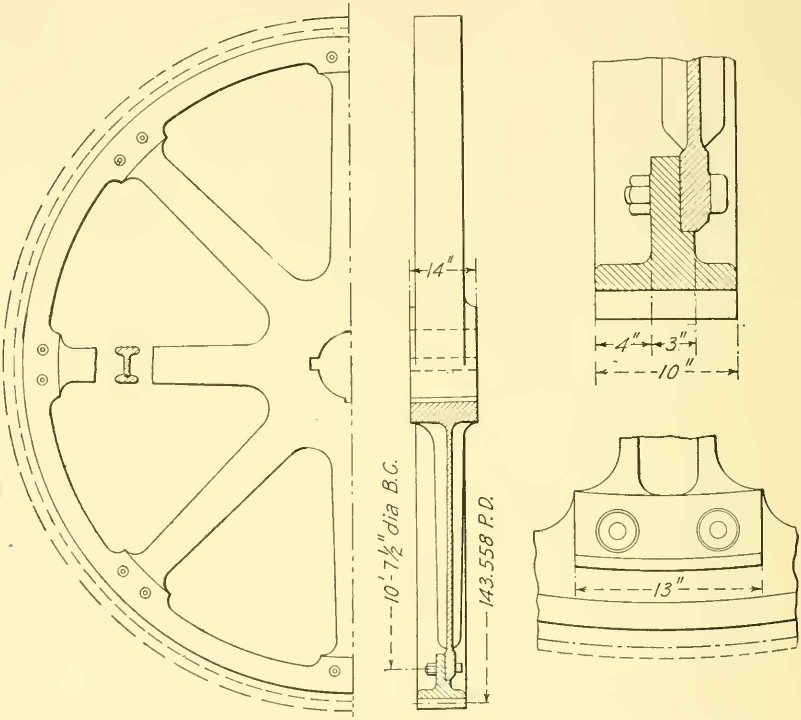


Fig. 17 Bull Wheel for 9-Cu. Ft. Dredge

57 *Bull Wheel.* The bull wheels or tumbler-shaft gears are cast of steel in sections, sometimes with a split and sometimes with a solid hub (Fig. 17). The rim is cast in one piece or in halves. Some designers use cut teeth, others rough cast. There can be no doubt but that the cut teeth run more smoothly, but for the rough work in hand the writer does not believe that the extra cost is warranted,

particularly since the teeth are soon worn down and the benefit of the cut teeth disappears. In order to prevent breaking, all sharp angles should be avoided in the design of the spokes. They are subjected to constant shocks and vibration, and the gears will invariably break at a sharp re-entrant angle should such occur at a vulnerable point. In order to make a snug fit and also to keep the rim from becoming elliptical, the spokes should either have a shoulder fitting on a machined inner edge of the rim, or the ends of the spokes should be turned to fit a machined shoulder on the rim. The latter method is preferable since it does away with sharp corners which, as explained above, are always points of weakness.

58 It has been common practice to use one large bolt to fasten each spoke to the rim. Two smaller bolts are better since a more even distribution of spoke cross-section can be maintained by this design and it gives a longer spoke end to bear against the machined rim. A good many spokes have been broken near the rim where the cross-section is ample but where a point of weakness exists owing to the re-entrant shoulder above mentioned.

59 *Intermediate Shaft Pinions.* The intermediate shaft pinions are made solid and as small in diameter as is consistent with good design. These pinions wear out quite rapidly and should be so arranged as to be easily replaced.

60 *Intermediate Shaft Gears.* The intermediate shaft gears are designed of a size to give the bucket line the desired speed. They are often made with separate rims so that they may be replaced when worn without throwing away the rest of the gear.

61 *Pulley-Shaft Pinion.* The pulley-shaft pinions are made similar to the intermediate shaft pinions and as small as good design will allow.

62 *Clutch.* Whether the digging motor is belted direct to the bucket-drive pulley shaft, or to a countershaft on the ladder-hoist foundations and from there to the bucket-drive pulley shaft, some form of friction clutch is used to connect and disconnect the bucket drive, and for purposes of safety in case the buckets encounter obstructions beyond their strength. Any of the standard forms of friction clutches may be used, but the author prefers the electro-magnet clutch and uses it in all his designs. It is by far the simplest to operate, is positive and will slip at exactly the same pull every time according to the amount of current sent through its coil by the rheostat controlled from the pilot house.

63 The clutch used is very simple in design (Fig. 18). A cast-

iron pulley is made so that there is a flat ring or web joining the spokes at about half the distance from hub to face. To this web is bolted a soft cast-iron ring. Between this and the pulley are inserted two thin sheets of copper and one of soft iron between the copper plates. These ring-shaped sheets are used in order to keep the lines of force where they are most wanted and to prevent the current making a permanent magnet of the pulley, shaft, etc., which would cause the clutch to drag when released. The pulley has a long hub bushed with bronze and runs free on the shaft. A long cast-iron hub with two feather keyways at 180 deg. and a web extending out to the same diameter as the ring on the pulley is made to slide along the shaft. Onto this web is bolted another soft iron ring similar to the one bolted to the pulley. An annular groove of rectangular cross-section is machined in this ring midway between its inner and outer circumference into which fits a coil of magnet wire. By introducing an electric current into this coil through controller rings, magnetic lines of force are induced which will draw the two soft iron rings together, the pressure depending on the amount of current put through and the number of turns in the coil. The edges of the soft iron rings

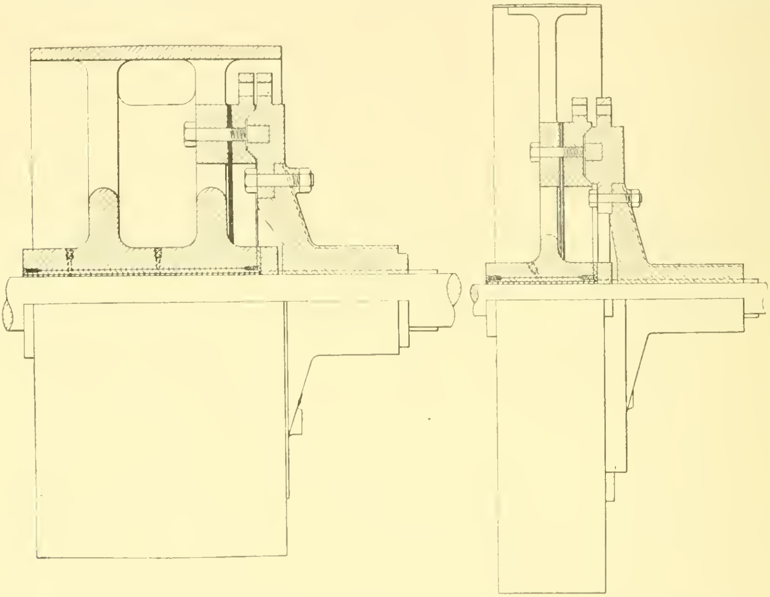


FIG. 18 MAGNETIC CLUTCHES FOR BUCKET DRIVE AND MAIN WINCH, 9-CU. FT DREDGE

are beveled so as to make a female joint on the pulley and a male joint on the sliding hub. The steeper the slope of these edges the less current will be required to do the requisite work, but if the cones are made too steep it will be difficult to disconnect the clutch. Forty-five degrees does very well. Good results are given by 440 turns of No. 16 magnet wire, and 4 amperes at 110 volts are put through the coil when working average ground. These figures are for a 200-h.p. clutch.

64 *Shafts.* The shafting for the bucket drive should be made of ample dimensions and of good material. Nickel steel annealed and a factor of safety of 10 are used by the author. The gears should be fitted very neatly and securely keyed.

65 *Bearings.* The upper tumbler-shaft bearings are made on an angle so as to have the bearing cap at right angles to the average line of pull of the bucket line. Cast-iron liners are sometimes used, but the author prefers a babbited bearing. The bearings should be well fastened so that they cannot slide forward, there being a very heavy pull in this direction. These bearings, like the others of the bucket drive, are made of cast steel.

66 The intermediate and pulley-shaft bearings are made of the ordinary type of babbited base and cap, but are heavier than standard and use very large diameter bolts, which should be made of a soft grade of iron or steel, since unless this is done they are likely to crystallize and break.

67 *Brake.* It is customary to have the pulley shaft extended and a brake wheel keyed on. This brake is operated from the pilot house and is used by the winchman to hold the buckets from going over the upper tumbler when the bucket line breaks, to stop quickly in case of an accident, and to hold the bucket line when making repairs or changing buckets.

68 *Pulley.* Standard medart pulleys are generally used. They give considerable trouble on account of broken spokes. The author has recently used with success a wooden bucket-drive pulley similar to that commonly employed in stamp mills, and on the last boat he designed a medart pulley with spokes made extra heavy near the hub and tapering to a little more than standard cross-section at the rim, since nearly all the trouble arose from spokes breaking near the hub. If a cast-steel hub and spokes could be made it would be the best pulley for the purpose. Several of the steel foundries say that they would not care to attempt to cast a spider with as small spokes as the standard medart and that a very heavy spoke would have to be

made in order to overcome shrinkage trouble. If spokes could be made of cast steel and of as light or lighter design than the standard medart it seems as if it would be an ideal pulley for dredge use.

69 *Foundations.* Too much attention cannot be given to making the supports for the bucket drive of very sturdy construction. In the first place these foundations are 20 or 30 ft. above the main deck and are subjected to constant and racking strains. If any portion of these supports gives it throws the shafting out of line with obvious results. One form of support now much used and considered very good has the upper cord of the main truss made high enough to take the upper tumbler-bearing supports directly on its top. By this method the main gantry is braced fore and aft in a most excellent manner and it is a much more rigid construction than where the

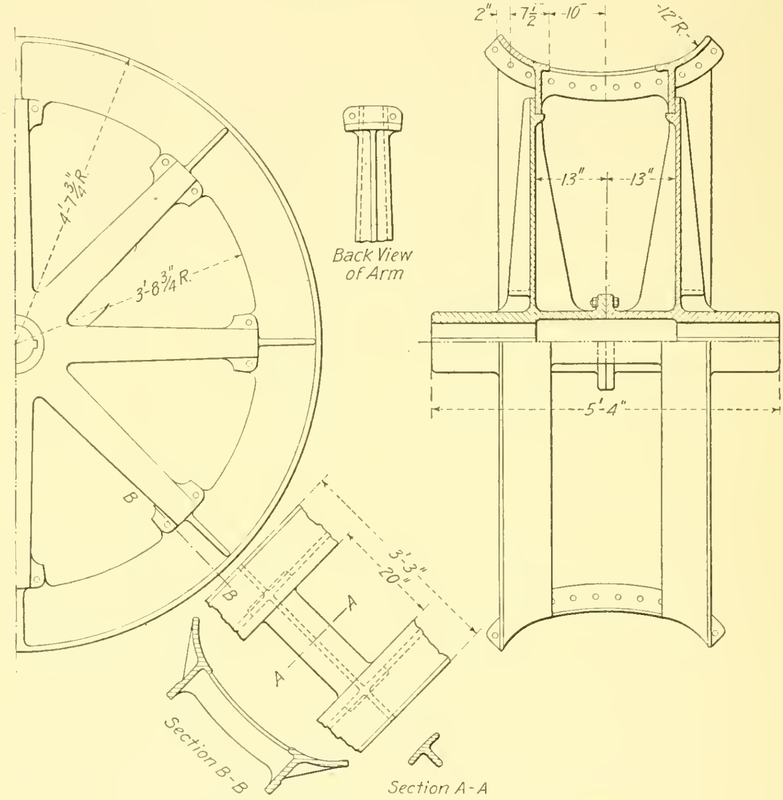


Fig. 19 Bucket Idler for 9-Cu. Ft. Dredge

gantry extends above the cord. Large steel castings are used to tie the timbers together and to support the bearings directly. The details vary on different dredges and apparently have all given good service. One point which should be carefully looked into when designing this part of the dredge is so to place all bolts that they may be readily accessible and replaceable.

BUCKET IDLER

70 Where the depth of gravel to be dug demands a long string of buckets, an idler (Fig. 19) is used to support the sag. This idler is located at the throat of the well as low down as convenient. It is made up of a cast-steel hub and a double set of spokes bolted onto a wide rim made to fit the curve of the bucket lip. The shaft is keyed to the hub and revolves in two bronze bushed bearings set on the deck or other convenient place.

CATCH-ALL

71 Below the dump hopper an inclined set of grizzly bars is put in. These extend as far forward as the sag of the buckets will allow. The bars are put $\frac{3}{4}$ to 2 in. apart. Below this grizzly is a collecting pan which directs the gravel to the forward end of a sluice with riffles, occupying the space between the gantry posts and sloping toward the after portion of the dredge. This sluice is run back as far as the grade will permit and then dumps its contents into riffled side sluices running forward one on each side of the well. These discharge into the well 15 or 20 ft. forward of the well throat. Water is furnished from one of the pumps and washes the material dropping through the grizzly bars.

DUMP HOPPER

72 The hopper into which the buckets dump diverts the gravel into the screen. It is made either with a steel lining or by having a depression left at its bottom which fills up with rocks and gravel, thus forming its own lining. It is obvious that the last method is much more economical than the steel-lined hopper and that so far as its bottom is concerned it will last indefinitely; the only difficulty is that unless the hopper is left of ample dimensions it is likely to clog up when digging large quantities of material, particularly clay. By using a steel lining for the bottom of the hopper a little space may be saved, and if a large quantity of clay is to be handled the latter method might be preferable, but for ordinary conditions the rock bottom seems to be all that is necessary.

73 The hopper is built up on three sides of the upper tumbler, the top being at about the level of the bucket lips as they go over the tumbler. The forward upward edge is built to such a height as to miss the bucket lips by a few inches when the ladder is in its lowest position, and it is of advantage to put inclined guide plates on each side of the bucket line to divert the slopover of the buckets into the

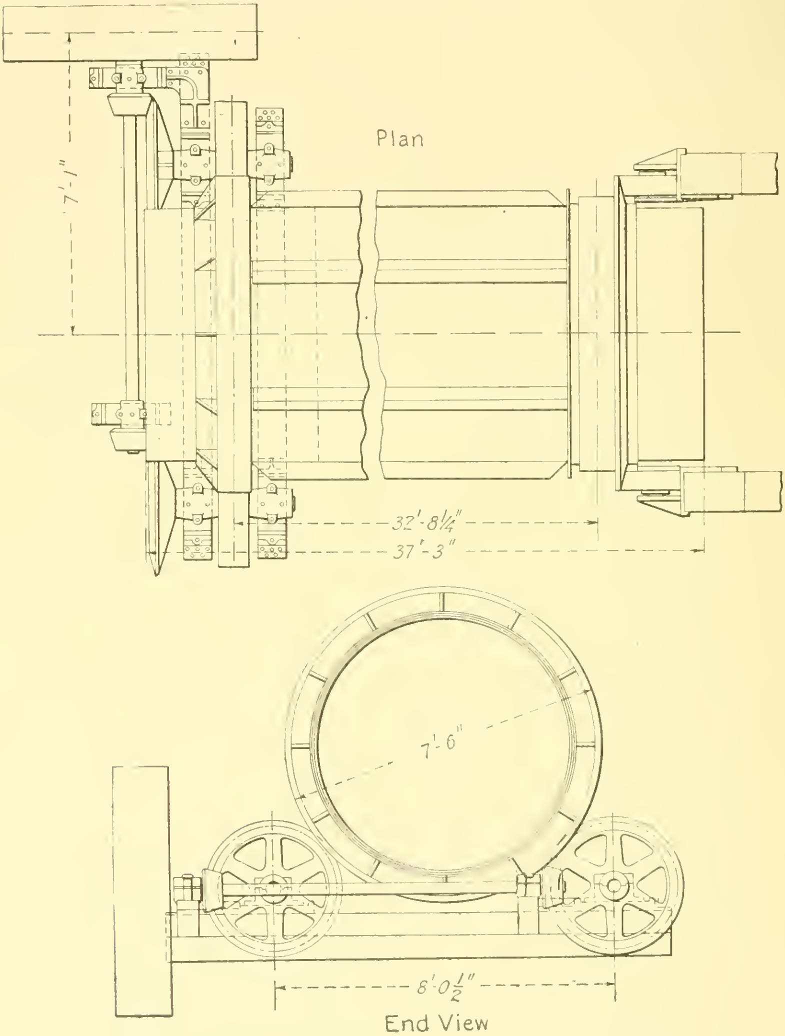


Fig. 20 Revolving Screen for 9-Cu. Ft. Dredge

hopper below. The rear vertical wall of the hopper is subjected to considerable wear by the striking of the rocks and gravel against it when the buckets dump and it should be lined with an easily replaceable steel plate. A good way is to suspend a $\frac{1}{2}$-in. plate from the top by means of a few bolts, leaving the bottom entirely free.

SCREEN

74 Two types of screen are in common use, the revolving and the shaking. The first dredges used the revolving screen, then the shaking type was introduced at Oroville and for a time most of the dredges were built in this way. On the Yuba it was found that these did not break up the clay in a satisfactory manner and revolving screens were introduced. This type proved better for this district, and since then many have gone back to the revolving screen even in other districts. The object of a screen is not only to size the material passing through it, but also to disintegrate and wash it. This the revolving screen does more thoroughly than the shaking screen where clay or cemented gravel is present. The shaking screen gives a more even distribution of the fines, requires less power to operate, and its plates last longer and are more easily replaced. For easily washed material the writer prefers the shaking screen, but for gravel hard to wash, the revolving type is decidedly preferable.

75 *Revolving Screen.* The design of the revolving screen (Fig. 20) has been well worked out and very little trouble is experienced with this part of the dredge. Most of the delays in its operation are caused by the necessary replacement of worn plates. These plates should be put in so as to be readily removable and not too close a fit made; rather leave considerable space between them, since if this is not done they will spread and be hard to take out. Bolts with countersunk heads on the inside and split washers under the nuts on the outside are used in preference to rivets. They hold as well and can be removed more readily.

76 The screens are built up in sections usually with cast-steel ribs at intervals to retard the movement of the gravel. These steel ribs also serve as a framework, to which are fastened the perforated plates. The size of perforations depends on the conditions and varies from $\frac{3}{8}$ to $\frac{3}{4}$ in.

77 Around each end of the screen is a steel ring or tire preferably made in halves so as to be readily removable. Two drive rollers on which the ring at the upper end of the screen rests are used on most of the older dredges, but a single drive roller under the center with

two side guide rollers is coming into use on the newer boats. The rollers driving the screen are themselves driven by beveled gears and pinions. Owing to the difficulty of keeping grit out of these gears they are made of manganese steel, with a soft iron core cast in the hub. Rollers are used at the lower end to support the screen and a pair of manganese steel thrust rollers are provided to keep the screen from moving toward the stern. The bevel gears are driven from a countershaft above the screen, the driving motor also being located there. The countershaft is used in order to reduce the speed properly, so that excessively large gears or pulleys need not be used.

78 At the lower end of the screen is a hopper which directs the coarse gravel onto a belt conveyor. In order to prevent clogging at this point the hopper should be placed on a grade of not less than 30 deg. and should be raised on the side on which the revolving screen moves upward, the gravel being carried up on this side of the screen.

79 *Shaking Screen.* The shaking screen (Fig. 21) is built with channel iron sides. The bottom is formed of angle iron cross-pieces, to which are bolted the perforated plates. The angles should extend beyond the sides so that the top of the channels may be braced from their ends. The screens are built in pairs and mounted tandem so as to balance each other, one moving forward when the other moves aft. They are suspended from the timbers above, some using adjustable, others non-adjustable rods. The upper and lower bearings for these rods should be made of ample size, since they wear surprisingly fast considering the small movement. The lower end of the after screen is constructed so as to direct the coarse material to the short discharge shoot onto the conveyor. This part of the screen is not perforated. The size of screen perforations depends on conditions and as in the revolving screen varies from $\frac{3}{8}$ to $\frac{3}{4}$ in.

80 The shaking screens are driven by means of four connecting rods, operated either by cranks or eccentrics on a thwartship shaft. The author is inclined to favor the eccentric drive owing to its larger wearing surface. If eccentrics are used they should have long hubs and double keyways, otherwise they are likely to work loose under the constant pounding. The drive shaft may be placed at any convenient point, but a central location between the two screens is perhaps the best. The bearings for this shaft are placed outside the screens, and as near as possible to the cranks or eccentrics, and should be long enough so that they will not beat out under the constant hammering. Buffer springs are sometimes used to take up the strain at the end of each stroke, but this practice is not common. The connecting rods are

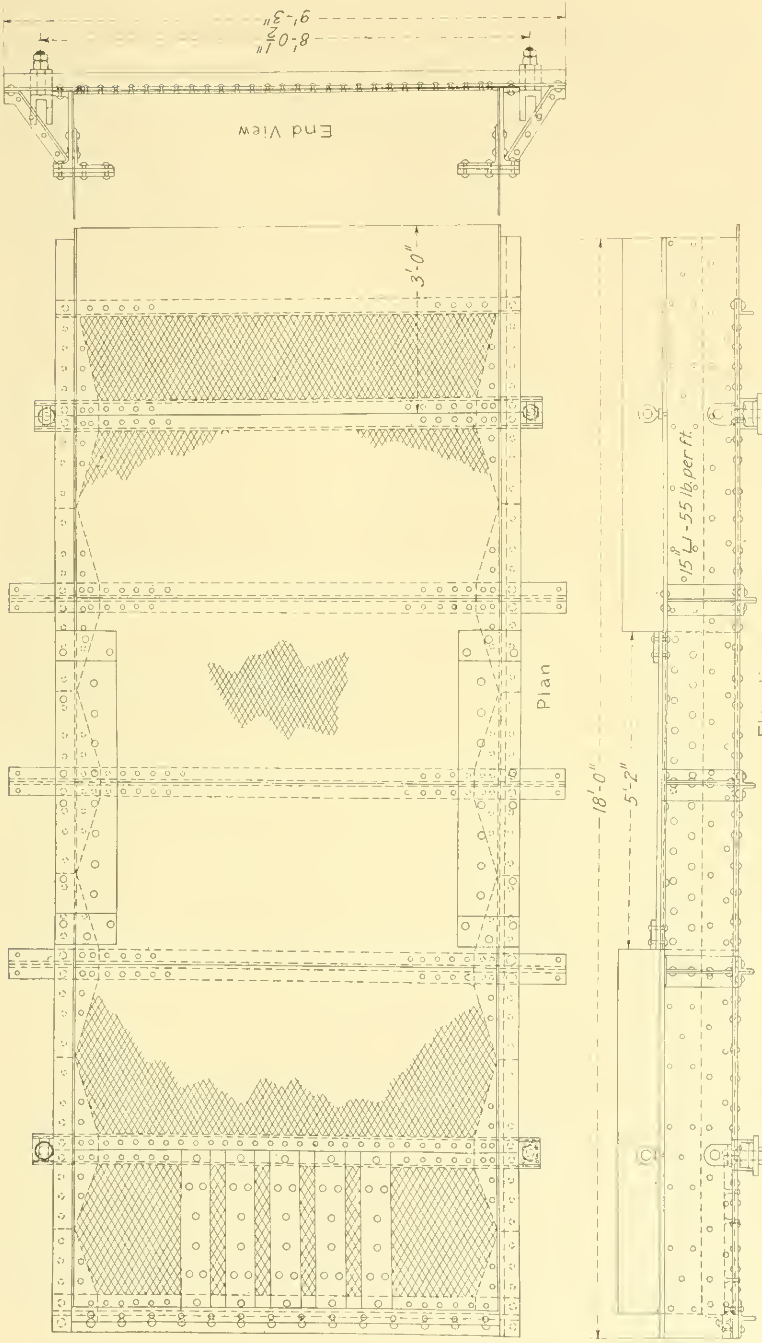


Fig. 21 Upper Shaking Screen, 7.5-Cu. Ft. Dredge

usually made adjustable and any of the standard methods of fastening rod ends may be employed.

81 *Sprays.* The ordinary form of spray for washing the gravel as it passes down the screen is a perforated pipe or pipes. The water from the high-pressure pump is used, and the holes vary from $\frac{1}{4}$ to $\frac{3}{4}$ in. diameter. These holes are so placed as to direct the water where most needed. The spray pipes should have quick-opening valves at their lower ends so that they may be flushed out when the holes become clogged with roots, grass and other small particles of matter. Where much clay has to be washed some of the dredges are using large-sized nozzles set in groups at each end of the screen. It is thought that the large streams break up the clay in a more satisfactory manner than the greater number of smaller-sized streams furnished by the perforated pipes.

STACKER

82 *Ladder.* The design of a stacker ladder is a simple matter, since the loads and conditions are fairly constant. The lattice girder is the most common type and the strains in each member may be readily ascertained by graphic methods. The author uses a factor of safety of eight for this ladder. The lower end is supported near the stern of the boat and should be so designed as to allow the ladder to move up and down and also to allow the ladder to swing from side to side. The upper portion is supported by a bridle near the end and one near the middle. The ends of a wire rope are made fast to these bridles, its middle portion passing over a sheave which is in turn attached to the stacker ladder hoisting blocks. Instead of a single loop arrangement I prefer to fasten one end of the rope to the ladder hoist block, from thence passing it around a sheave at the upper bridle, then over another at the ladder hoist block, fastening the end to the middle bridle. This puts nearly double the supporting power at the upper end and prevents the buckling upward of the ladder when the dredge is surging badly.

83 *Conveyor Drive.* The common method of driving the belt conveyor is by means of a motor set on supports above the ladder 15 ft. or so back from its upper end. The motor is belted to a pulley shaft mounted near the end of the ladder, onto which is keyed a pinion with cut teeth which meshes into a cut gear on the conveyor belt pulley shaft. The author recommends a large size drive pulley covered with rubber belting. In order to make the belt contact greater an idler is placed near this pulley which brings the belt up and in con-

tact with it for a large proportion of its circumference. By mounting the motor inside the ladder near the upper end a direct gear drive may be used, but this method has not been found as satisfactory as the belt drive described above. A silent chain drive is now being used a great deal. It allows the motor to be set nearer the drive and is said to work very well.

84 *Conveyor Belt.* Rubber conveyor belts are used and should have an extra thickness of rubber on the wearing side. The most important point is to select rubber of the very best quality.

DISTRIBUTOR

85 Below the screen is a hopper or distributor which is used to distribute the screened material onto the gold-saving tables. Here the ingenuity of the engineer may have full sway. The main object is to get the screened gravel evenly distributed on the gold-saving tables, and the way that it is accomplished makes very little difference. The distributor should be designed so that a certain amount of adjustment will be allowed to meet varying conditions. Where a shaking screen is used the problem is simpler than for a revolving screen.

GOLD-SAVING TABLES

86 This part of the dredge belongs more to the province of the mining than the mechanical engineer, so it will not be discussed at any length in this paper. Suffice it to say that the gold-saving tables should be specially designed to meet each different set of conditions. They occupy the greater portion of the dredge back of the main gantry and may be built either of plate steel or wood. The author prefers steel. The tables are covered with riffles made of angle iron or strips of wood covered with strap iron. The fine material is discharged either at the stern or some distance aft according to conditions.

LADDER HOIST

87 The ladder hoist (Fig. 22) is now usually driven by the digging motor from a countershaft located on the main deck. In a few cases it is driven from the bucket-drive pulley shaft on the main gantry. Owing to the load it has to carry it is made very heavy. A structural or cast-steel base is provided, on which are mounted the bearings. Single gearing is used and ordinarily the teeth are not cut. A friction clutch is provided on the pulley shaft to connect this part of the dredge machinery. From the standpoint of rope efficiency the drums

should be made much larger than is common practice, but excessively large drums are not warranted, unless the sheaves through which the same rope passes are made of corresponding dimensions. This entails increased construction cost, but the author is inclined to the opinion that it would reduce operating costs sufficiently to warrant some increase in this direction beyond common practice.

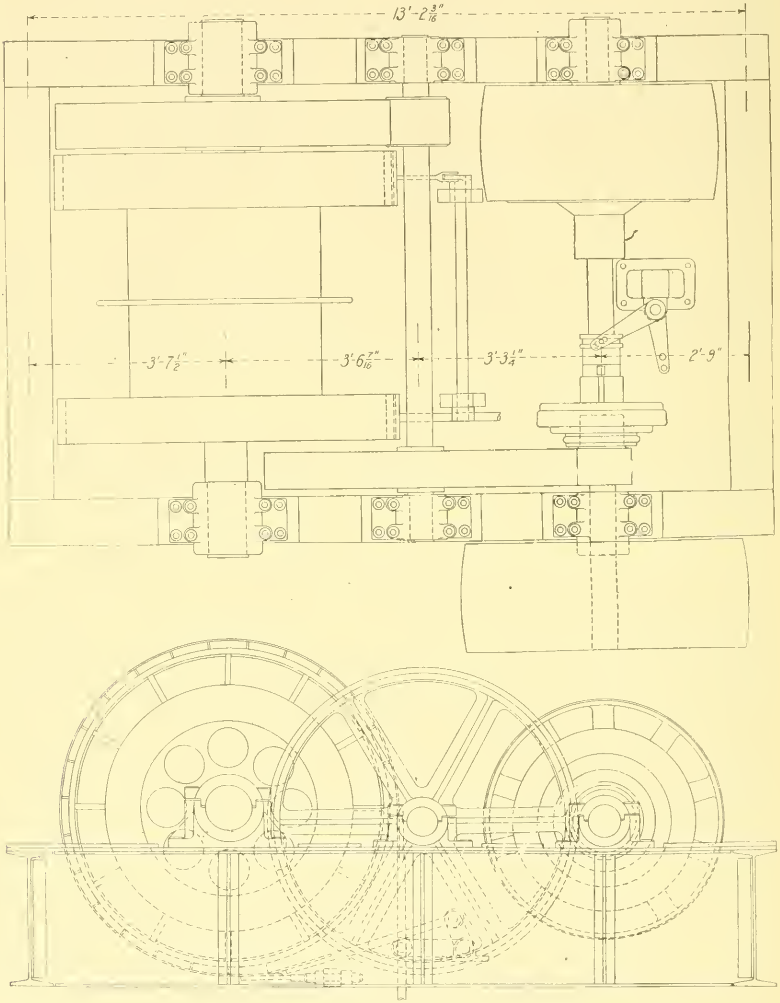


Fig. 22 Ladder Hoist for 9-Cu. Ft. Dredge

88 The brakes on the ladder hoist must be adequate in capacity

and made so that there may be no possible danger of their giving way. If the brakes on the main winch should give way little damage is likely to occur, but if they fail on the ladder winch a broken digging ladder is the probable result, if nothing worse. The following arrangement has been found very satisfactory. Two band brakes are used, one being operated by hand from the pilot house, the fixed end of which instead of being fastened to the deck is attached to a lever arm, which through a cross shaft operates the other brake, thus giving almost unlimited power with very little effort.

89 On most ladder hoists the drum-shaft gear is keyed to the drum shaft and it is nearly always located very close to the drum. It is a much better plan to design the side of the drum in such a way that the gear rim can be bolted to it, thus doing away with the gear spokes, making a much stronger job and taking all driving strain off the drum shaft.

MAIN WINCH

90 The main winch (Fig. 23) operates the swinging lines, both bow and stern, raises the spuds, and is usually fitted with one or two head-line drums for wrecking and repair work and to step up with when one spud has been broken. The winch is driven by a variable speed motor which together with the levers actuating the clutches is operated from the pilot house. Some form of friction clutch is commonly used on each drum. The writer has for some time been using an electro-magnet clutch on the pulley shaft of the winch similar to the one described for the bucket drive, and jaw clutches for each drum. The jaw clutches are extremely simple and require no attention, whereas a friction clutch is likely to get out of adjustment. Also each winchman wants his clutch set differently and unless great vigilance is exercised they will be constantly adjusting these clutches, which means lost time. The friction clutches on each drum are easier to operate, but with a little practice the jaw clutches give perfect satisfaction.

91 A good many dredges have a separate drum mounted on the after part of the dredge driven from the countershaft of the screen drive and is used to raise and lower the stack ladder. The drum is driven by a worm gear of such pitch that it will not run backwards from the weight of the ladder. Other dredges have an extra drum mounted with the main winch for this purpose. It is kept from reversing by a pall and ratchet. Considering the little use this drum gets its location and design seem to be of very little moment, but a worm drive and separate drum mounted aft are preferable.

92 *Swinging Lines.* On deep ground and for the larger dredges the bow swinging lines pass from the drum to a sheave or combination of sheaves located near the bow, then to a sheave on the shore, and from there to the lower end of the ladder. By this method of rigging very little side strain is put on the digging ladder or well hole. The disadvantage of this method is the necessity of a shore sheave and the consequent wear and time lost in moving and handling it. Where the ground is not too deep, a single line, which is simple to operate but which puts a large side-bending strain on the ladder and well hole is used. If the ladder and hull are built strong enough, this is not an objection. For the 13- and 16-ft. dredges a single line would have to be very large and would hardly be advisable.

93 *Brakes.* All winch drums are provided with band brakes operated from the pilot house. The connection between brakes and clutches and pilot house are made through bell cranks, rods, etc.

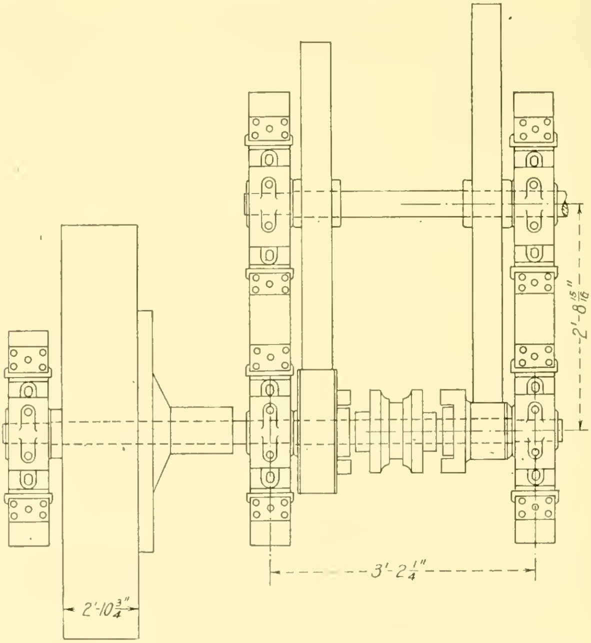


Fig. 23-a Magnetic Clutch and Drive for Main Winch, Fig. 23-b

Flexible wire rope running over sheaves is used in several instances for the brakes.

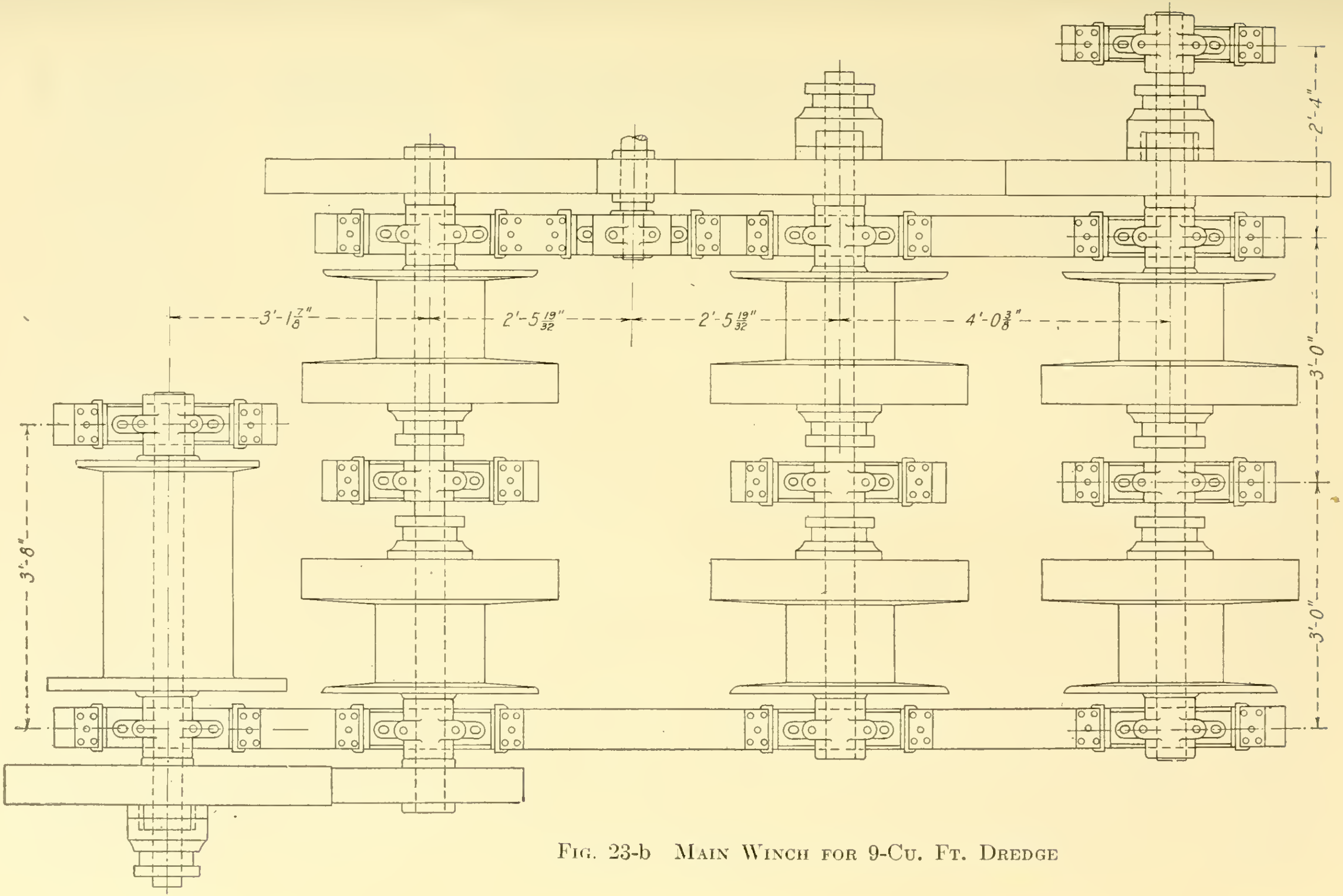


FIG. 23-b MAIN WINCH FOR 9-CU. FT. DREDGE

94 *Foundations.* Cast iron, cast steel, structural steel and wood are used for foundations. The author has been using wood in his recent designs on account of its producing less noise and vibration than metal foundations.

WIRE ROPE

95 Wire rope is used on the dredges for hoisting the digging and stack ladder, spuds, for all the swinging lines and for guying the gantries. On account of the small diameter sheaves, the necessity of the ropes being under water part of the time and the general hard service they get, their life is short as compared with ropes used for most other purposes.

96 Some dredge constructors use the regular open and closed sockets for their guy rope ends, and others think this practice is dangerous and use clips. The writer has never had any trouble with standard rope sockets if properly attached to the rope end. This may be done by first spreading the wire strands, treating them with dilute hydrochloric acid, inserting in the socket with the strands spread broom fashion, and then filling with melted zinc. The ends of the wires should not be turned over, but left straight. If turned over some are likely to get more strain than others, and to break and cause trouble.

97 Different makes and types of wire rope are used. The author's experience points to standard 6/19 plow steel hoisting rope for ladder, spud and side lines and 6/7 crucible cast steel standing rope for the guys. Hot Stockholm tar makes a good dressing, also most of the rope greases to be had on the market. Whatever dressing is employed it should be used freely.

SHEAVES

98 The sheaves used for the various purposes are made of cast steel in preference to cast iron. They are bushed with bronze or cast iron and their hubs made as long as possible. When long hubs cannot well be used, as in multiple blocks, the pins should be made of large diameter, so that the pressure will not be too great on each unit of resisting surface.

PUMPS

99 Three centrifugal pumps are ordinarily used on the gold dredge. The high-pressure pump should be designed to have a working head of at least 60 ft.; more is better if the gravel is at all hard to wash. This pump furnishes the water for the spray pipes or jets in the screens and is direct-connected to its motor.

100 The low-pressure pump is likewise driven by a direct-connected motor and should have a head of 20 to 30 ft. This water is piped to the tables where needed, depending on the nature of the gravel and the arrangement of the gold-saving tables.

101 The priming or fire pump is usually a two-step pump with a working head of 100 ft. or more. This pump is used in case of fire, for washing down decks, in cleaning up, for pumping out the bilge, and for priming the larger pumps.

102 All pumps should be fitted with both foot and check valves Bypass piping equipped with the requisite valves should be put in to be used for priming. The foot valves are provided with a grating, and the suction should be still further protected by a wire netting box attached to the side of the dredge. If this box be made of ample dimensions, say, 8 ft. by 15 ft., a $\frac{3}{8}$-in. mesh will work well. If a smaller box be used, $\frac{1}{2}$- or $\frac{5}{8}$-in. screen will have to be used, otherwise it is liable to get stopped up.

MOTORS

103 Three-phase induction motors are used on all standard California dredges, variable-speed for the digging and winch motors and constant-speed for the other pieces of machinery. Lately a form of variable-speed motor has been used for the stacker and screen drive, which gives a better starting torque for getting these parts under way and is particularly useful when it is necessary to start under full or overload. Any of the standard types of motor give most excellent results if the proper sizes are provided.

TRANSFORMERS

104 It is customary to bring the current onto the dredge at 2200 or 4400 volts, then transform down on the dredge with three oil-cooled transformers to 440 volts. Many of the later boats are using 2200-volt motors, thus avoiding the use of transformers altogether. Beside the three main transformers, another small one reduces the current to 110 volts for lighting purpose. All of the transformers are mounted in steel or asbestos-lined compartments opening to the outside of the dredge. They have pipe connections which allow the oil to be drained off and conveyed overboard to a point some distance from the transformers. These precautions are necessary in order to secure the best insurance rates and are to be recommended as a safeguard against fire. Another precaution which might prove useful is to provide the transformer housings with plate steel doors hung from

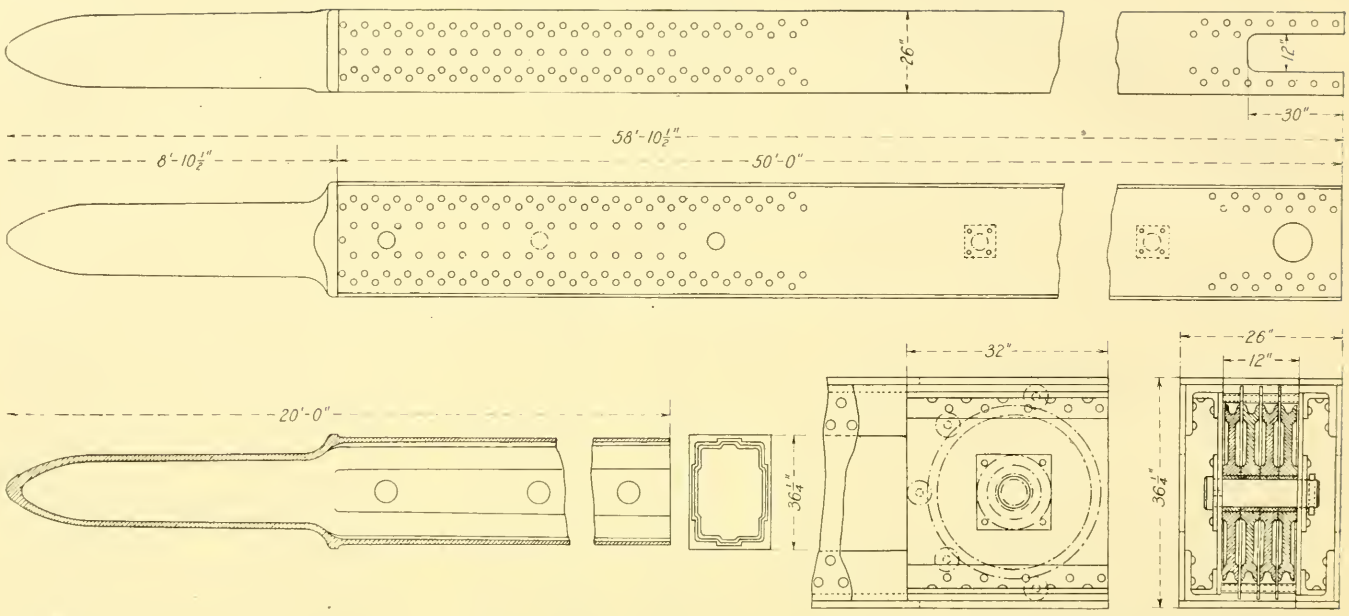


Fig. 24 Spud for 5-Cu. Ft. Dredge, showing Sections

the top with an automatic latch at the bottom and so constructed as to be readily dropped and latched in case of fire.

WIRING

105 The electric current is brought on board the dredge on floats in a three-conductor armored cable at a point near the stern, this part of the hull having the least movement. An oil switch is located near this point and is often so arranged that it may be instantly thrown out from the pilot house. From this switch the current is conveyed to the transformers in case low-voltage motors are used and from there the secondary is distributed to the different switchboards. The latest boats use conduits and condulets for all the wiring. If open wiring is used the conductors should not be stretched too tightly and they should all be stranded. The single wires are likely to break under the severe vibration of digging and the movement of the hull and superstructures. Stranded conductors even with the conduit wiring are recommended by the writer. For the motors located on the lower deck their wiring connections can be made through the hold. For the other motors the best method must be determined according to the conditions.

SPUDS

106 The early California dredges used a head line to dig on and even after the spud system was introduced it was a mooted question which was the better. The standard California type dredge uses the spud system (Fig. 24) exclusively, the head line being abandoned except in a few cases where the nature of the gravel or other conditions are unusual. At first, wooden spuds were used, then one wooden and one steel, the wooden spud being used to step up with and the steel one to dig on. Now both spuds are often made of steel. This plan is by far the best, since if one breaks the other may be used to dig on, using the head line to step up with. If only one steel spud is provided and a break occurs, the dredge must be shut down at once and the broken spud taken out, repaired and put in again before any digging can be done. Several forms of spud are used, and their make-up can best be understood by referring to Fig. 24, which shows views and cross-sections of a common design. An extra cover plate riveted to the tension side of that portion of the spud having the greatest strain adds strength with comparatively little increased weight.

107 The lower ends of the spuds are protected by cast-steel points, which extend far enough into the structural part to give ample

riveting area. The later designs are made longer than the older ones (Fig. 22). At the bottom they are acorn-shaped and change gradually from a circular to a rectangular cross-section at the point where they enter the structural portion of the spud, and they often extend 8 or 10 ft. below this point.

108 Heavy car springs are often used in the spud frames to reduce the shocks of digging and those using them think that they lessen the danger of breaking very much. This is doubtless true, but the author is of the opinion that it also reduces the digging capacity of the dredge and that the best remedy for broken spuds is to build them stronger.

CRANES AND REPAIR DEVICES

109 The modern dredges are provided with traveling or boom cranes covering the heavy machinery so that repairs and replacements may be made expeditiously and without calling in more men than the regular dredge crew. A thwartship I-beam with traveler, or a swinging boom covering the forward portion of the dredge and bucket line, is used for changing buckets. Brackets are riveted to the ladder, into which chains are hooked to hold the bucket line after parting. It is well to have an I-beam or at least an eye or hook well secured above the ladder hoist, main winch, pumps, transformers and screen. Over the bucket line a thwartship traveling crane is most useful. It should be of sufficient capacity to lift the upper tumbler, shaft and gears and should extend far enough so that these parts may be lowered over the side of the dredge. If a hatchway is provided through the upper deck on each side of the bucket drive this crane may also prove useful for handling parts on the lower deck.

HULL

110 The hull is built of Douglas fir and is proportioned to accommodate properly the machinery which it supports. Before designing the hull the general dimensions and weights of all machinery should be determined and the hull built accordingly. The depth largely depends on the weight to be supported, the beam on the gold-saving area desired, the length and width of well on the dimensions of the digging ladder, and the digging ladder in turn, on the depth of gravel to be dug. The distance from well to stern is determined by the length of screen and the general distribution of machinery fore and aft. The hull rides on an even keel when digging at an average depth and should have a free board of not less than one-fourth its total depth.

111 The cross-section is rectangular, with the deck slightly crowned. Thwartship frames are used, the bottom planking being spiked to the bottom thwartship timbers, the decking to the upper timbers or deck beams, and the side planking bolted to the upright side posts. Besides these, two or more pairs of posts are put in each frame and to these the well planking and bulkheads, or fore-and-aft trusses are bolted. Clamps or fore-and-aft strengthening timbers are bolted inside the frames at the corners where the posts join the deck beams and bottom thwartship timbers. The size of these clamps depends on the size of the hull. Drift bolts are driven in the side planking and bulkheads, each bolt passing through $2\frac{1}{2}$ planks. They may be put in as thickly as desired, and add considerable strength to the planking and bulkheads. Four-inch deck and bottom and 6-in. side planking is commonly used. The stern is often planked with the same size as the sides, put edgeways instead of flat. At the point where the spuds are located a short bulkhead or extra bracing is often used. Just aft of the well and below the bucket drive, one or more vertical cross trusses are often used, likewise horizontal cross bracing is put in on top of the thwartship frame timbers along the compartments adjacent to the well and extending some distance aft from the well throat.

112 The bow is made narrower than the rest of the barge, the frames being shortened and the side planking steamed and bent around them. How much this portion of the hull should be narrowed down will depend on the width of cut it is desired to make, together with the distance the digging ladder projects beyond the bow. Using one spud as a center and drawing the outline of the hull, digging ladder and cut to scale, will graphically illustrate how much to bring in the bows so that the dredge may dig its way along any desired width of cut.

113 The above is a general description of the most common type of hull construction. The writer has been using what he considers a somewhat stronger construction, but one which is more expensive. Fore-and-aft stringers are laid below the thwartship timbers. The posts are bolted to both the fore-and-aft and the thwartship timbers, the bottom planking being laid athwartships. Clamps are used above the thwartship timbers the same as in the other form of construction, the difference being that there is an extra set of fore-and-aft timbers, to which the bottom planking is spiked, this planking running athwartships instead of fore and aft. This construction requires more lumber and labor, but is stronger, and by using thwart-

ship planking full lengths can be used, doing away with all butt joints. The tendency of dredge hulls is to sag along the fore-and-aft center line. Where fore-and-aft planking is used this movement of the hull tends to open up the seams, but where thwartship planking is used the strain is lengthways of the planking. When a hull is new these weaknesses do not show, but after years of service all such little things count, and since the life of a hull determines the life of a dredge, it pays in the long run to use every precaution possible to add to the stability and length of life of the hull. Solid fore-and-aft bulkheads are recommended, also the use of well plates made up of 6 in. by 14 in. planking (for the 7 to 9 cu. ft. dredge), laid horizontally below the deck beams and filling the roof of the first compartment on each side of the well for 30 ft. each way fore and aft from the throat of the well. These well plates are particularly useful in dredges having long well holes.

114 Another plan which will add strength at small cost is to put in diagonal wooden braces from the fore-and-aft timbers near the bottom of the intermediate bulkhead to the clamp near the top of the well hole. This will aid materially in preventing sag toward the well hole.

115 Still another form of strengthening construction being used, particularly on the larger boats, is an overhead thwartship truss with heavy hog rods running diagonally from the upper chord near the sides of the dredge to the bottom of the hull at the well, thus preventing sag at this point.

116 The bottom, sides, bow, stern and deck are all calked with oakum and the seams pitched or similarly treated. The inside is treated with carbolinium, Stockholm tar, painted or left without any treatment whatever. On the outside below the water line the planking may be painted or not as desired. Above the water line all timber work is thoroughly painted. Before putting timbers together all joints are painted with white lead, mineral paint, or coated with tar or carbolinium.

117 The deck beams are extended beyond the sides of the barge at the after portion of the dredge. Braces are put under these in order to support the housing uprights. This gives extra room for gold-saving area or passageways. Hatchways are provided for entrance into each compartment, also a system of ventilation should be installed, using either mechanically driven fans or natural ventilation induced by cowled ventilators. Proper ventilation will do much towards prolonging the life of the hull. Sea cocks are often installed

in order to sink the dredge in case of a fire which has gone beyond hope of being extinguished. If sea cocks are used they should be located near the bows where a hot fire in the housing will not prevent their being approached and quickly opened.

118 *Main Truss.* A large proportion of the California dredges have a truss along the sides of the well and extending from bow to stern gantry, with wooden chords, posts and braces and steel hog rods. This truss is made 15 to 25 ft. high, the upper chord often being used to support the upper tumbler bearings and the upper end of the digging ladder. In the earlier dredges there was a tendency for the hulls to go down at bow and stern and hump up near the throat of the well. This truss assists in preventing this condition, strengthens all the gantries and spud frame, and makes an excellent support for the housing, screens, etc. It should be designed as a truss supported at the middle with weights suspended at each end.

119 *Bow Gantry.* At the bow is a gantry (Fig. 25) which supports the forward end of the digging ladder, the details varying in the different dredges. A steel cap of box or double I-beam section on four posts is a common type. In some dredges the four posts are parallel; others have two posts parallel to the well sides and two sloping inward joining the first at the cap. Still others have the four posts parallel for half their length, the two outside ones being cut at this point, and from here diagonal braces run to the intersection of cap and inside posts. The whole gantry is inclined forward in order that it may have a more direct pull on the digging ladder. In a good many of the California dredges the gantry posts go through the deck and are stepped on heavy foundation timbers or castings near the bottom of the hull. A few dredges have rigid foundations for these posts on the deck, and at least one uses a socket casting into which the posts fit loosely.

120 This gantry has thwartship bracing and is guyed by ropes or tie rods to the main gantry, hull timbers or both. The top chord of the main truss runs to the middle portion of this gantry and is fastened to it by means of steel plates. It is also customary to run a brace diagonally from near the cap to the top of the first truss post. Some form of pin and plate clamp is provided for the bow gantry cap, to which is attached the ladder hoist blocks and gantry guys.

121 *Main Gantry.* The main gantry is a support for the bucket drive and the after end of the digging ladder. It has a very severe duty to perform and should be built in a most substantial manner. The author prefers to place a post under each bearing and use heavy

lattice bracing between the posts. Too many plates should not be used to tie the timbers together, and arrange matters if possible so that all bolts will be accessible. Where many plates are used it is very difficult to assemble the parts and in case of repairs the delay

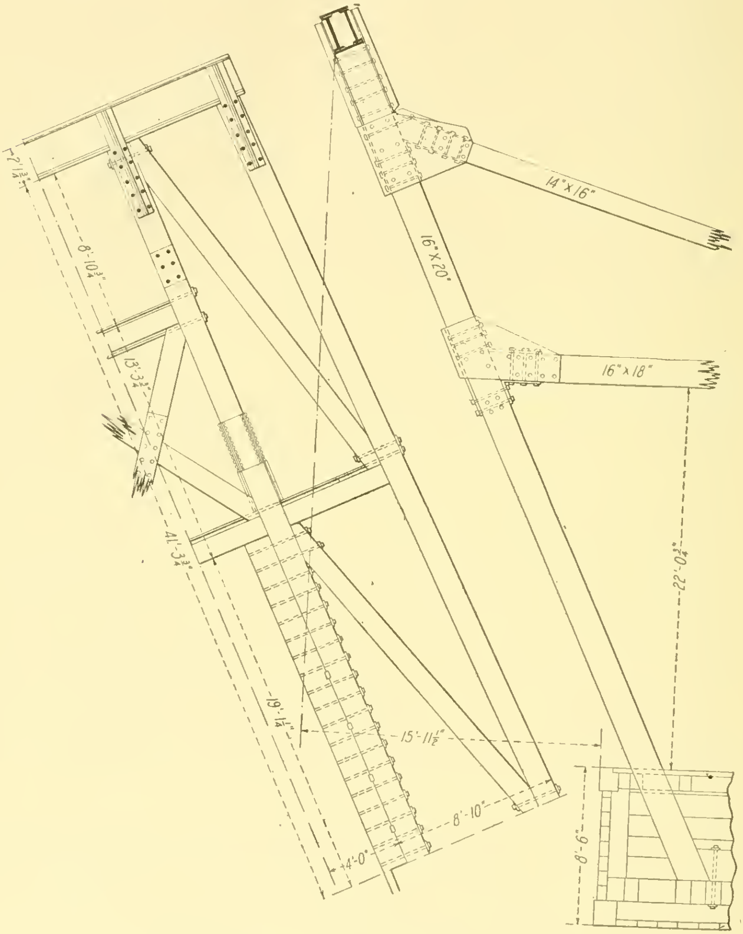


Fig. 25 Bow Gantry, 9-Cu. Ft. Dredge

is great in taking apart and re-assembling, owing to the difficulty of lining up the holes in the different plates.

122 *Stern Gantry.* The stern gantry (Fig. 26) supports the spuds and the stack ladder and must be made high enough to raise the

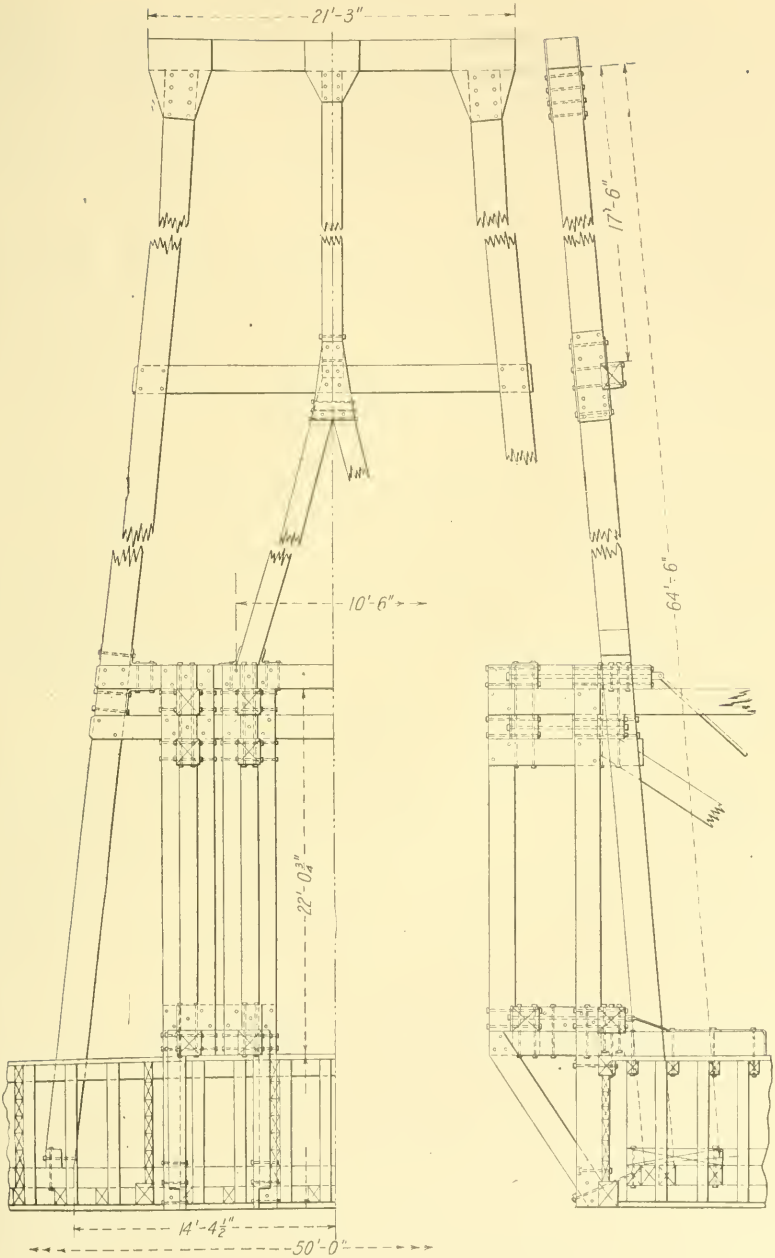


Fig. 26 Stern Gantry, 9-Cu. Ft. Dredge

spuds so that they will nearly clear the bottom of the hull. It is inclined slightly aft so that the spud hoist blocks will be vertically above the center of the spuds. The design is simple, two, three or four posts being used with a wooden or steel cap. Clamps are used for the spud hoist blocks, ladder support and guy ropes. The posts may rest on foundation timbers or castings located near the bottom of the hull or on the deck.

123 *Spud Housing.* At the stern of the dredge the two spuds are enclosed in a housing which allows them to slide up and down but holds them in a vertical position. At some point above the deck, usually at the elevation of the upper chord of the main truss, heavy timbers are framed around the spud, with tie rod connections to the hull or main gantry. This framing together with the tie-rod connections resists the tendency of the upper part of the spud to move backward as the buckets engage the gravel and thrust the hull toward the rear. This clamp must be made strong enough to withstand the full digging power of the dredge, increased to some extent by the slight fore-and-aft movement of the hull and the consequent momentum of the full weight of hull and machinery. The writer does not approve of running the tie rods to the main gantry, since no matter how strong this part is made the constant pulling and jerking on one side will tend after a time to throw the bucket-line shafting out of line. The guy rods should be run into the hold or to some other part which does not support shafting.

124 Many different spud-housing designs are used, but the present tendency seems to be to use heavy castings covering a large area of the stern to resist the forward pressure of the spud and a structural or cast-steel clamp 20 ft. or so above the deck. In order to keep the spud from moving backward heavy steel keepers are used which can quickly be removed when it is necessary to change spuds. The timber construction will work well enough, but it is likely to get loose in time, and it is difficult to design a wooden structure so that it will be at the same time strong and easily removable. Whatever form of spud housing is used it should be so enclosed that small rocks can not lodge where they will be caught between the spud and its guide.

125 *Housing.* The after portion of the dredge is housed in, this housing covering the gold-saving tables, pumps, main winch, ladder hoist and transformers. The after central portion is extended up and covers the screen and screen drive. A covering should also be provided for the bucket drive, but this is not essential. The roof of the housing is made with a slight crown or slope to the sides and

covered with painted canvas, ship fashion. The roof joists should be made heavy enough to support a considerable weight, since in repairing it is often convenient to lay down one of the big gears or the like, and for this reason the flooring should be at least $1\frac{1}{4}$ in. thick, or made of two thicknesses of planking. The stern and sides along the gold-saving tables are not usually boarded up. It is thought that an unobstructed view lessens the danger of amalgam stealing.

126 *Pilot House.* The pilot house from which the digging motor and winches are handled is usually located on the starboard side of the upper deck above the main winch and a little forward of the bucket drive. This is the common location, but the pilot house on the central line of the dredge above the bucket line and just forward of the bucket drive seems preferable. The only objection to this location is that the lever connections to the winches are a little more complicated. This location gives an excellent view in all directions around the dredge and down the bucket line. By proper arrangement of gratings the main winch may be seen. The bucket drive, stacker and spuds are also within sight of the winchman. In the writer's opinion there is no question as to the proper location for the pilot house, and all his dredge designs have their pilot houses well up in the center of the boat.

DIMENSIONS

127 In Table 1 the more important dimensions and some other data of several California gold dredges built at different times, of different sizes,, and for different conditions are given. Most of the data were kindly furnished by the makers, and will serve to give a general idea of typical dimensions. In checking over the figures furnished several discrepancies were noted, but on the whole the figures are no doubt approximately correct.

CONSTRUCTION COSTS

128 The construction costs vary greatly, of course, according to the quality of workmanship and material desired, facilities of the builders in the way of properly equipped shops and foundries, and the geographical situation of the ground on which the dredge is to be built. The following may be considered a fair average of many cost records in California, for rough estimating purposes:

129 For all the machinery, including motors, pumps, wire rope, electric supplies, etc., $12\frac{1}{2}$ cents per lb., delivered on the ground; for installing, $4\frac{1}{2}$ cents; or a total of 17 cents per lb. for the machinery installed. The lumber costs about $30 per 1000 ft. at Portland, and

this together with freight, bolts, nails, hog rods, steel plates, oakum, paint, etc., will make the hull material cost about $50 per 1000 ft. of lumber used; labor of building costs about $40 per 1000 ft., giving $90 per 1000 ft. as a total cost of the completed hull. In addition the direct costs chargeable to hull or machinery, insurance, traveling, superintendence, camp equipment, temporary buildings, shop, derrick, office expense, design, etc., amount to between $10,000 and $25,000, depending on whether new designs have to be gotten out, what construction tools and equipment are on hand, the size of the dredge, and location of the ground on which it is to be built. For a a complete dredge, $180 per ton, on a basis of its displacement, is a fair average.

TABLE 1 GENERAL DATA ON CALIFORNIA GOLD DREDGES

Name of maker	Risdon	Bucyrus	Link Belt	Risdon	Marion	Marysville Dred'g Co.
Date built	September 1897	1907		1910	1905	1911
Capacity bucket, cu.ft.	3.2	5	5	5.6	7.5	9
Depth to dig below water line, ft.	20	38	35	30	65	65
Depth to dig above water line, ft.	8	10	12	10	10	10
Nature of digging	Loose	Medium hard	Hard	Medium	Medium	Medium
Hull:						
Displacement with all machinery	3 ft. 6 in.	5 ft. 9 in.	5 ft. 8 in.	5 ft. 3 in.	6 ft. 6 in.	6 ft. 2 in.
Length, ft.	70	102	106½	88	115	115
Depth, ft.	5	7 ft. 9 in.	7 ft. 10½ in.	7 ft. 6 in.	8	8½
Width, ft.	29	36	40	36	40	50
Overhang on each side, ft.	0	2	....	0	2½	4
Length of well, ft.	42	56 (approx.)	51 ft. 1 in.	48	63	63
Free board, ft.	1½ (approx.)	2 ft. 3 in.	2 ft. 2½ in.	2 ft. 3 in.	1½	2 ft. 4 in.
Side planking, ft.	3	4	4	4	4	6
Bottom planking, ft.	3	4	4	4	4	4
Height of bow gantry above deck, ft.	22	36	34 ft. 6 in.	34	39 ft. 6½ in.	37
Height of stern gantry above deck, ft.	24	50	61 ft. 8 in.	36	58 ft. 9 in.	58
Height of main gantry above deck, ft.	16	23	21 ft. 8 in.	21 ft. 6 in.	20 ft. 2 in.	22
Total amount of lumber in hull, gantries, housing, etc., ft.	75,000	136,000	263,600	156,000	300,000	400,000
Digging ladder:						
Weight, lb.	14,000 (approx.)	48,400 (approx.)	53,575	33,000	79,000	94,400
Distance between centers, ft.	40	87	84½	71 ft. 6 in.	114 ft. 1 in.	115
Extension beyond bow, ft.	12 (approx.)	25½	26	18	38	43
Width, ft.	3	4½	5 ft. 8 in.	3 ft. 8 in.	4 ft. 7½ in.	4 ft. 7½ in.
Maximum depth girder, ft.	24	7	5 ft. 6 in.	54	8	8
How upper end is supported	Fixed hanger - shaft with telescope bearing	Concentric	Steel pin, 8 in.	Fixed hanger - shaft with telescope bearing	Concentric	Concentric
General design	Plate girder	Plate girder	Plate girder	Plate girder	Lattice girder	Lattice girder
Stacker:	Bucket elevator	Belt conveyor	Belt conveyor	Bucket elevator	Belt conveyor	Belt conveyor
Length ladder, ft.	42	90	106	72	136	139
Width ladder, ft.	3 ft. 2 in.	4	3 ft. 8¾ in.	3 ft. 8 in.	3 ft. 8 in.	4 ft. 4 in.
Depth ladder, in.	15	5	4	15	8	7
Weight ladder, lb.	12,000	18,000	15,000	19,365	22,500	24,000

TABLE 1 GENERAL DATA ON CALIFORNIA GOLD DREDGES—*Continued*

Name of maker	Risdon	Bucyrus	Link Belt	Risdon	Marion	Marysville Dred'g Co.
General design	2 I-beams	Lattice girder	Lattice girder	2 I-beams	Lattice girder	Lattice girder
Width belt, in.	Buckets 15 in. pitch	30	30	Buckets 15 in. pitch	32	32
Speed belt	48 buckets per min.	350 ft. per min.	Variable	54 buckets per min.	350 ft. per min.	400 ft. per min.
Horsepower motor	Driven by main engine	15	20	10	25	35
Maximum height of discharge, ft.	20	30	35	30	50	54
Bucket line:	Open connected	Close connected	Close connected	Open connected	Close connected	Close connected
Number in line	30	82	93	40	93	84
Maximum speed of buckets per min.	16	22	22	14	19	50
Weight bucket complete, base, hood, lip, pin, bushing, lb.	570	1300	1490	1200	2187	2268
Pitch of bucket, in.	24	28 5/16	24½	25	32¼	36
Number front eyes	2	2	2	2	3	2
Number back eyes	2	1	1	2	2	1
Length back eye, in.	4	16	19⅜	6	8⅛	16¾
Width front eye, in.	4	3⅝	6½	6	3¾	4
Diameter pin, in.	1⅞	4⅛	4½	2¾	4⅝	5¼
Length pin, in.	10½	23¼	30⅞	12½	2 ft. 3 5/16 in.	24⅞
Ladder roller:						
Number on ladder	6	12	19	10	17	17
Diameter in.	8	14	12	12	14	14
Diameter, shaft in roller, in.	2	3 15/16	3 7/16	3½	4½	5 7/16
Diameter shaft in bearing, in.	2	3⅜	3 7/16	3½	3 15/16	5
Length shaft in bearing, in.	6	11⅛	....	8	12	11⅞
Material used	White iron	High carbon and manganese steel	Semi steel	Manganese steel	High-carbon steel	Chrome steel
Weight roller and shaft, lb.	280	1030	1008	778	1160	1140
Upper tumbler:						
Diameter shaft in tumbler, in.	8	14	14	11	17	17
Diameter shaft in bearing, in.	8	12	12	11	14	14
Span between bearing	4 ft. 6 in.	6 ft. 6 in.	....	5 ft. 2 in.	9 ft. 3 3/16 in.	9 ft. 3 3/16 in.
Weight complete with shaft and plates, lb.	3010	11,200	10,185	6,220	18,750	21,310
Lower tumbler:						
Diameter shaft in tumbler, in.	6	10¼	11¾	10	11¼	12
Diameter shaft in bearings, in.	6	9	7¾	10	10	10

TABLE 1 GENERAL DATA ON CALIFORNIA GOLD DREDGES—*Continued*

Name of maker	Risdon	Bucyrus	Link Belt	Risdon	Marion	Marysville Dred'g Co.
Length of shaft,	4 ft. 2 in.	4 ft. 9¼ in.	6 ft. 5⅞ in.	5 ft. 3 in.	4 ft. 11¾ in.	5 ft. 3½ in.
Maximum height side flanges at corners above wearing plates, in.	7¼	6⅝	9½	11	12½	11¼
Thickness side flanges at top and bottom, in.	1–2¼	1⅝–3⅛	2¼–3	1½–3¼	1–1⅜	2
Inside flare of side flanges	....	2 in. in 12 in.	Curved	....	$\frac{11}{16}$ in. in 12 in.	Straight
Weight complete with shaft and plates, lb.	4,176	10,000	8,355	7,746	11,340	12,758
Ladder hoist:						
Total weight, lb.	Part of main winch	14,800	20,000	5,660	....	39,000
Diameter of drum, in.		18	30	18	20	3 ft. 6 in.
Diameter of drum shaft, in		6½	6$\frac{7}{16}$	....	8	9½
Speed of drum, r.p.m.		19.2	9.6	....	12.8	7.6
Maximum speed ladder line, ft. per min.	....	....	....	10	67	100
Horsepower required to raise ladder at above speed	....	....	....	35	....	120
Diameter of sheaves, in.	....	30	30	36	30	42
Main winch:						
Total weight, lb.	10,385	23,700	32,500	24,200	....	23,275
Horsepower of motor	12	20	35	25	25	25
Diameter of drums, in.	15	16	18	18 and 24	18	16
Diameter of drumshaft, in.	3½	4⅞	4$\frac{13}{16}$	5⅛ and 7	4$\frac{13}{16}$	4$\frac{13}{16}$
Maximum number r.p.m. drum	....	14	20.5	2	9	16
Minimum number r.p.m. drum	....	2.6	....	....	2.5	4.7
Maximum speed of side swing at end of digging ladder, ft.	....	62	....	....	17.5	38
Minimum speed of side swing at end of digging ladder, ft.	....	11.5	....	....	5	11
Speed of raising spud, ft.	....	10	....	....	4.5	9.5
Horsepower necessary to raise spud at above speed	....	10	....	....	6	15

TABLE 1 GENERAL DATA ON CALIFORNIA GOLD DREDGES—*Continued*

Name of maker	Risdon	Bucyrus	Link Belt	Risdon	Marion	Marysville Dred'g Co.
Bucket drive:						
Horsepower digging motor	50 h.p. steam	100	100	100	150	200
Diameter and face engine pulley, in.	66	96 x 24	86 x 21	96	96 x 24	96 x 25½
Pitch diameter and face pulley shaft pin	....	10.82 in. P.D. x 7 in. F.	11.52 in. P.D. x 6½ in. F.	....	11.936 in. 8 in. F.	11.936 in.–8¼ in. F.
Speed pulley shaft, r.p.m.	....	160	143	156	113	115
Speed intermediate shaft, r.p.m.	....	44	22.5	56	21	21
Pitch diameter and face intermediate shaft gears	....	39.67 in. x 7 in.	74.49 in. x 6 in.	47¾ in. x 6 in.	62.87 in.–8 in. F.	62.87 in.–10 in. F.
Pitch diameter and face intermediate shaft pinions	....	13.5 in. x 8 in.	14.32 in. x 10 in.	....	20.136 in.–10 in. F.	20.136 in.–10 in. F.
Speed tumbler shaft, r.p.m.	8	4½	4.5	7	3.1	3
Height tumbler shaft above deck,	....	23 ft.	25 ft. 2½in.	....	22 ft.5¼ in.	24 ft. 6 in.
Pitch diameter and face tumbler shaft gears (bull wheels).	....	9 ft. 11 in.–8 in. F.	71.62 in.–9 in. F.	....	143.55 in.–10 in. F.	143.55 in.–10 in. F.
Weight bull wheels, lb.	2,100	5,500	3,110	3,200	8,985	10,200
Spuds:						
Total weight including all castings, lb.	....	20,400	43,800	....	32,000	36,000
Total length, ft.	....	50	58 ft. 10 in.	....	60	61
Width, in.	....	24	26	....	24	24
Depth, in.	....	36	36	....	36	36⅞
Type of construction.	....	Box type	Box girder	....	Center web	Center web
Screen:						
Type	Revolving	Revolving	Shaking	Revolving	Revolving	Revolving
Total length, ft.	20	25½	32	24	30	36 ft. 3 in.
Width or diameter	3 ft. 6 in. diameter	6 ft.	7 ft. 4 in. upper 7 ft. 11 in. lower	4 ft. 6 in. diameter	6 ft. diameter	6 ft. diameter
Size of holes	⅜ in. dia.	⅜in.to½in.	⅜ in.	⅜ in. dia.	½in.to⅝in.	½ in.
Grade	1½ in. in 12 in.	2 in. in 12 in.	1⅞ in. in 12 in.	1½ in. in 12 in.	2 in. in 12 in.	2 in. in 12 in.
Horsepower of motor	Driven by main engine	20	20	15	35	50

TABLE 1 GENERAL DATA ON CALIFORNIA GOLD DREDGES—Continued

Name of maker	Risdon	Bucyrus	Link Belt	Risdon	Marion	Marysville Dred'g Co.
Number r.p.m. or strokes per min.	12	7	....	9	7	8
Gold-saving tables:						
Total area, sq. ft.	160	800	....	370	1600	2400
Grade	1¾ in. in 12 in.	1$\frac{7}{16}$ in. in 12 in.	1¼ in. in 12 in.	1¾ in. in 12 in.	1⅜ in. in 12 in.	1⅜ in. in 12 in.
Wood or steel	Steel	Wood	Steel	Steel	Wood	Steel
Width of bays, in.	28	36	30	32	33	36
Dimension of riffles	Cocoa matting and expanded metal	1$\frac{1}{16}$ in. x 1¼ in. wood	1 in. x 1 in. x $\frac{3}{16}$ in. L.	Cocoa matting and expanded metal	1¼ in. x 1¼ x $\frac{5}{16}$ in. L.	1¼ in. x 1¼ x $\frac{5}{16}$ in. L.
High-pressure pump:						
Horsepower of motor	....	15	100	30	50	100
Head, ft.	18	65	70	31	50	68
Quantity of water, gal. per min.	3000	500	2800	2400	....	3200
Size suction pipe, in.	....	4	12	14	10	12
Size discharge pipe, in.	....		10	9	8	10
Make of pump	Risdon	Yuba Con. Co.	Worthington	Risdon	Worthington	Abner Doble
Low-pressure pump:						
Horsepower of motor	No low-pressure pump	50	No low-pressure pump	....	25	35
Head, ft.		60		18.6	25	25
Quantity of water, gal. per min.	....	2000	....	2200	....	3800
Size suction pipe, in.	....	8	...	....	10	12
Size discharge pipe, in.	....			9	8	12
Make of pump	....	Yuba Con. Co.		Risdon	Worthington	Abner Doble
Fire pump:						
Horsepower of motor	....	Use high pressure	5	5	10	10
Head, ft.	....		65	40	90	100
Quantity of water, gal. per min.	....		150	....	....	....
Size suction pipe, in.	....		3	3	4	2½
Size discharge pipe, in.	....		2½	2½	3	2
Make of pump	....		Worthington	Krogh.	Worthington	Abner Doble
Lines:						
Size ladder hoist, in.	⅝ in.–	⅞ to 1	1	⅞ in. diameter	1	1⅛
Size stacker hoist, in.		¾	¾	1½ in. diameter	¾	¾
Size spud hoist, in.	....	¾	¾	....	⅞ and ¾	¾
Size swinging lines, in.	½–in. rope 300 ft.	¾ to ⅞	¾ to ⅞	⅞ and ¾	1 and ¾	1
Total weight machinery, tons	90	260	305	220	300	400

RESULTS OF TESTS ON THE DISCHARGE CAPACITY OF SAFETY VALVES

By E. F. Miller

ABSTRACT OF PAPER

The paper gives the results of a series of tests made on the discharge capacity of 3-in. and 3½-in. locomotive pop safety valves at varying lifts under 200 lb. boiler pressure, also results of tests on the discharge capacity of 3-in. and 3½-in. inspector valves of the flat-seated and bevel-seated types under 100 and 150 lb. gage pressure. In all of the tests the steam was condensed in a surface condenser and the condensation weighed. The tests were run from 30 minutes to 1 hour in duration so that errors of weighing were reduced to a minimum. In all of the tests the valve was set a definite distance from its seat and held rigidly, the spring of the valve having been removed.

Results of the tests are given both in the form of a plot and numerically.

RESULTS OF TESTS ON THE DISCHARGE CAPACITY OF SAFETY VALVES

By E. F. Miller, Boston, Mass.

Member of the Society

The tests quoted in this article (Tables 1 and 2) were made during the spring and summer of 1910 for the information of the Crosby Steam Gage & Valve Company, by whom permission has been given to present the contents of the report to the Society, believing that the results will be of some value to its members.

2 In all the tests the valves were without springs and were set a definite distance from their seats and held rigidly during the tests. They are shown in Figs. 1, 2 and 3 as modified for these tests. As a result of the tests the locomotive valve is now made as shown in Fig. 4. In order to avoid unequal expansion, the metal of the valve body and the metal of the spindle were made the same in the case of the locomotive valves; difference of expansion was similarly obviated as far as possible in the inspector valves. The spring was replaced by a spindle attached to the valve. This spindle extended through the top of the valve and carried at its free end a pointer which traveled over a graduated cylinder. The lower part of the spindle was threaded with a 20 thread. The graduated cylinder at the top was divided into five parts, each representing 0.01 in. A motion of the pointer of approximately 1 in. corresponded to a 0.01 in. lift of the valve from its seat. Tests on the 3-in. valves were run with lifts set at 0.10,0.08, 0.05 and 0.02. Tests on the $3\frac{1}{2}$-in. valves were run with the same lifts at 100 and 150 lb. pressure, but the capacity of the condenser prevented running the $3\frac{1}{2}$-in. valves with 0.10 in. lifts at 200 lb. pressure.

3 The valves were connected with the boilers through a line of 5-in. pipe, into which two Babcock & Wilcox boilers of 500 boiler h.p. discharged. The 5-in. pipe connected with a 10 ft. length of 10-in.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

pipe on the end of which was a blank flange 2 in. thick. To this flange the safety valve under test was bolted (see Fig. 5). This flange was bored on the bottom with a hole considerably larger than the inlet to the valve. The entrance edge of this hole was rounded with a curve of 1 in. radius. On the other side of this blank flange and enclosing the safety valve was a 10-in. flanged tee. The outlet of this tee led to the condenser. The end of the tee on the straight run was covered with a blank flange. Between tests this blank flange on the end of the tee was removed and the setting of the valve changed. After each test the valve was examined to see if it had moved from its previous setting. The steam passing through the valve was condensed in a surface condenser vented to the air through a $2\frac{1}{2}$-in. pipe. The condenser was tested immediately before and after each test and was found to be absolutely tight. The condensed steam was pumped to two weighing tanks, each of about 1500-lb. capacity.

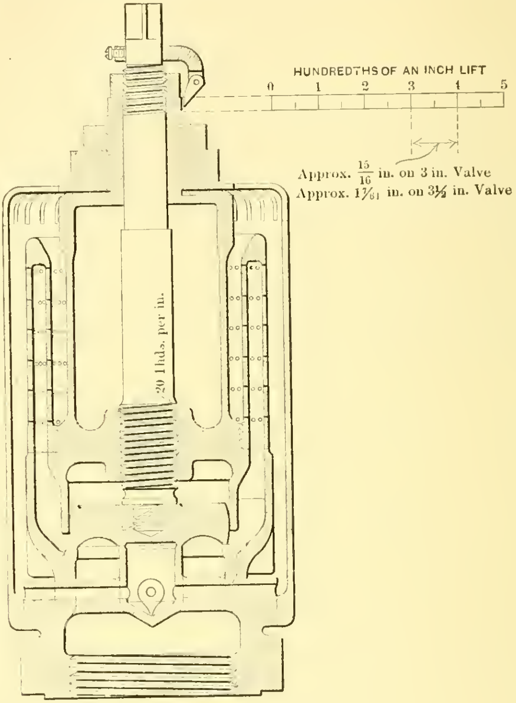

HUNDREDTHS OF AN INCH LIFT
0
1
2
3
4
5
Approx. $\frac{15}{16}$ in. on 3 in. Valve
Approx. 1 7/64 in. on 3½ in. Valve
20 Thds. per in.

Fig. 1 Crosby Muffled Locomotive Pop Safety Valve

4 The steam was led from the boiler through a small separator

in the boiler room, then through a second separator located about 20 ft. from the safety valve. A calorimeter was attached to the 10-in. pipe near the safety valve and the quality of the steam determined. In all of the tests the steam was practically dry.

5 To see whether or not there was any pressure in the muffler or in the outer valve casing, a copper pipe was connected and led through a stuffing box outside of the 10-in. tee and a low-pressure gage attached. The boiler gage used was a Crosby standard test gage attached to the 10-in. pipe. In nearly all of the tests this gage was read at 1-minute intervals. In recording the pressures averages were taken from five readings in each case.

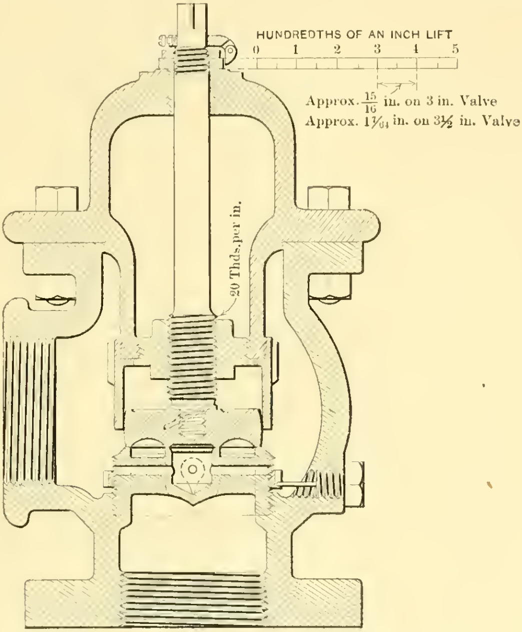

HUNDREDTHS OF AN INCH LIFT
0 1 2 3 4 5
Approx. $\frac{15}{16}$ in. on 3 in. Valve
Approx. $1\frac{7}{64}$ in. on $3\frac{1}{2}$ in. Valve
20 Thds. per in.

Fig. 2 Crosby Flat Seat Inspector Pop Safety Valve

6 The pressure coming on the valve tends to make the opening through the valve greater than the "lift as set," due to the yielding of the metal. To determine this yielding, the valves were placed in a small Riehlé testing machine and a load equal to the steam pressure on the bottom of the valve applied to the valve. The additional opening due to this yielding was determined by micrometer measurements.

7 All tests with low lifts were made at least 60 minutes long to minimize any error due to a difference of level in the hot-well under the condenser.

8 The condensed steam is pumped out of the hot-well by a pump operated through a float and valve. A difference of about 1 in. is required ordinarily to make this float operate. One inch difference in level in the hot-well means an error of 9 lb. of water.

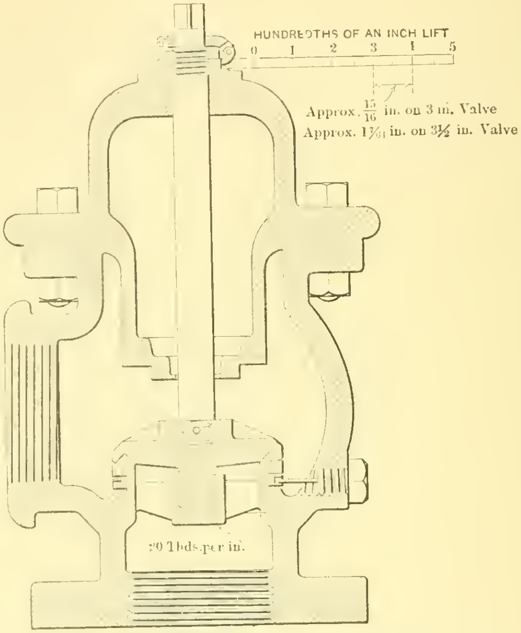

HUNDREDTHS OF AN INCH LIFT
0 1 2 3 4 5
Approx. $\frac{15}{16}$ in. on 3 in. Valve
Approx. $1\frac{7}{64}$ in. on $3\frac{1}{2}$ in. Valve
20 Thds. per in.

Fig. 3 Crosby Bevel Seat Inspector Pop Safety Valve

9 The different results are given both in tabular form (Tables 1 and 2) and in the shape of plots (Figs. 6 and 7). The different tests on one valve have been reduced to a common pressure by assuming the discharge through a given orifice to be proportional to the absolute boiler pressures. For such small variations in pressure as there were in these tests this assumption can introduce no error. Tables 1 and 2 give summaries only of results obtained in the tests. Tables were prepared, however, giving the results in detail, an example of which is shown in Table 3 which gives a part of the detailed records[1] summarized in Tables 1 and 2.

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[1] Other of the records may be consulted in the rooms of the Society.

10 In the locomotive valves the muffler was screwed down to its lowest position. In the inspector valve flat seat the ring was screwed down so as to leave the holes half open. There was no ring on the bevel-seated valves.

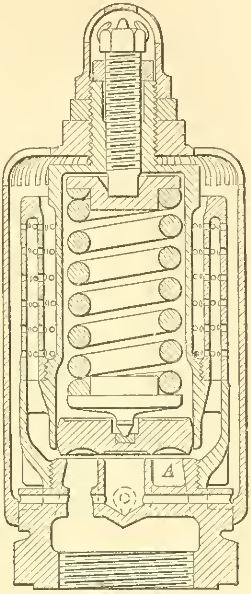

Fig. 4 Sectional View of Crosby Muffled Locomotive Pop Safety Valve as now Made

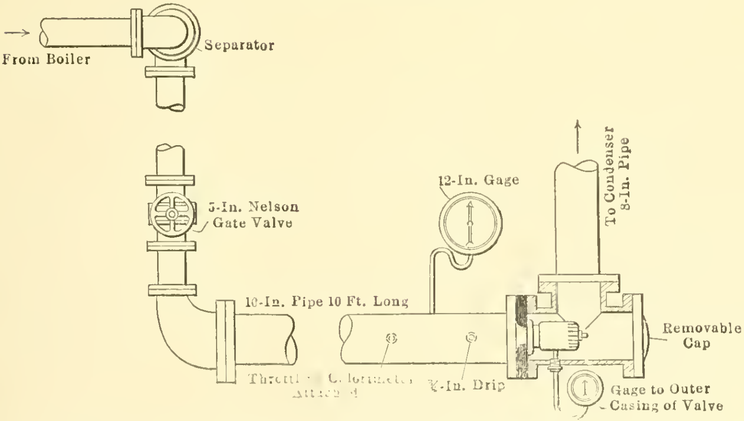

Fig. 5 Arrangement of Piping for Safety-Valve Tests

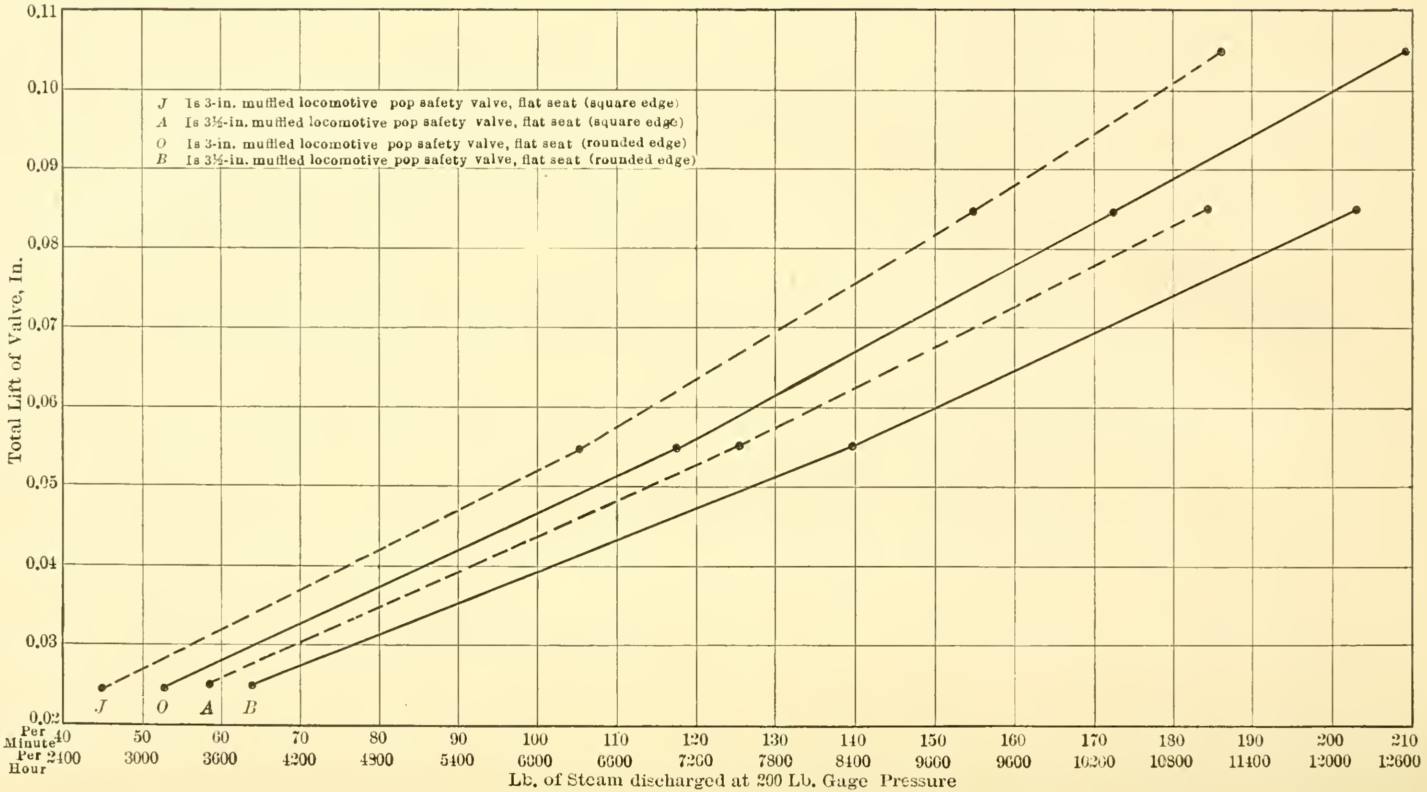

FIG. 6 RESULTS OF TESTS ON CROSBY LOCOMOTIVE POP SAFETY VALVES

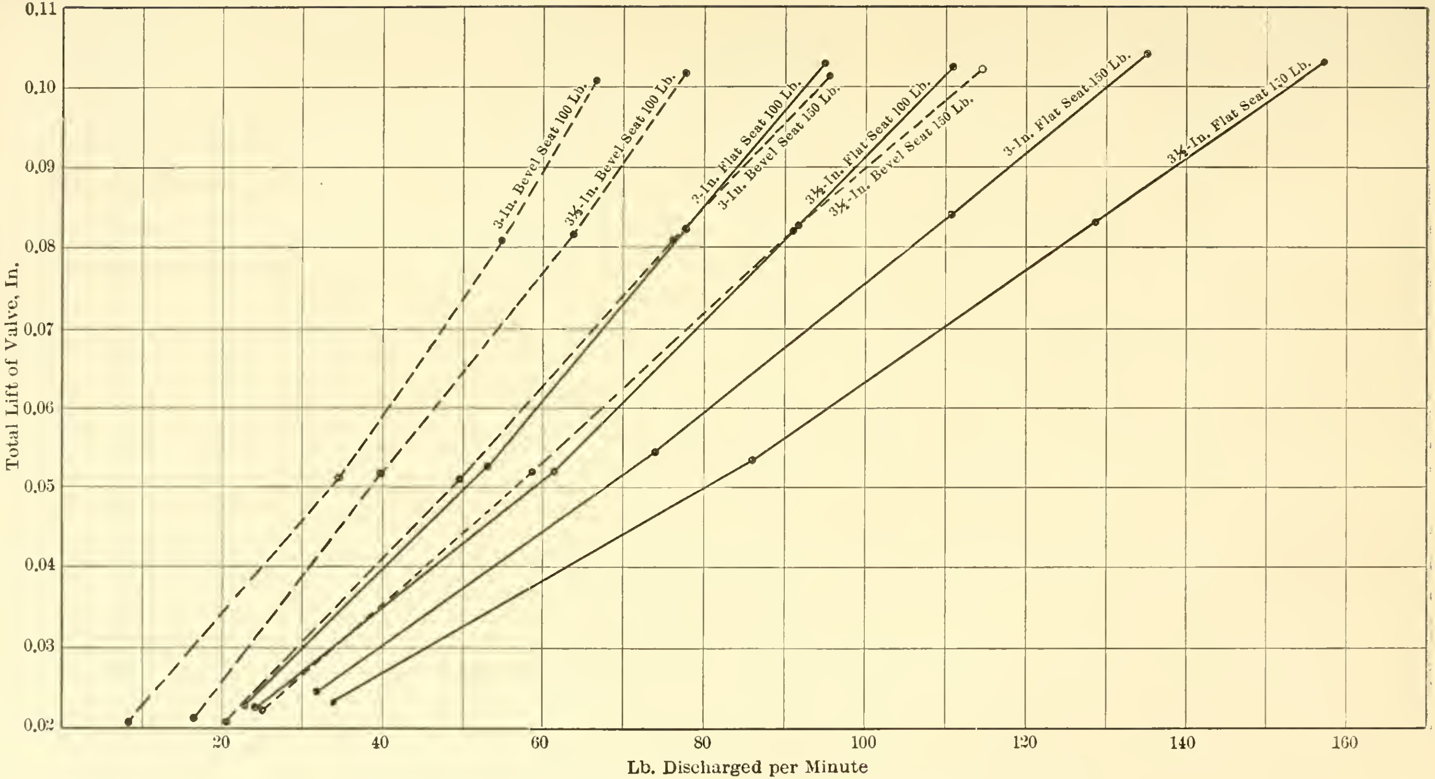

FIG. 7 RESULTS OF TESTS ON CROSBY INSPECTOR POP SAFETY VALVES

ACCURACY OF THE VARIOUS READINGS

11 The lift of the valves could be set with an accuracy as great as that of the 20-thread screw. As the total motion was only $\frac{1}{10}$ in. it is probable that the error from this source is not over half a thousandth of an inch. The difference in expansion due to temperature between the body of the valve and the valve and its spindle was obviated in the case of the locomotive valves by making these

TABLE 1 SUMMARY OF RESULTS ON CROSBY MUFFLED LOCOMOTIVE POP SAFETY VALVES

3-In. Flat Seat, Square Edge, Valve marked "J"

Lift of valve as set	0.02	0.05	0.08	0.10
Total lift including yield of metal	0.0247	0.0547	0.0847	0.1047
Lb. discharged per hr.	2845	6313	9342	11222
Boiler pressure gage	209.0	201.0	201.5	201.0
Lb. discharged per hr. reduced to 200 lb. gage	2743	6284	9277	11170
Lb. discharged per min. reduced to 200 lb. gage	45.7	104.7	154.6	186.2

3-In. Flat Seat, Rounded Edge, Valve marked "O"

Lift of valve as set	0.02	0.05	0.08	0.10
Total lift including yield of metal	0.0247	0.0547	0.0847	0.1047
Lb. discharged per hr.	3309	7250	10414	12442
Boiler pressure gage	209.0	205.8	201.3	198.3
Lb. discharged per hr. reduced to 200 lb. gage	3178	7059	10352	12542
Lb. discharged per min. reduced to 200 lb. gage	52.9	117.7	172.5	209.0

3½-In. Flat Seat, Square Edge, Valve marked "A"

Lift of valve as set	0.02	0.05	0.08	0.10
Total lift including yield of metal	0.0251	0.0551	0.0851	0.1051
Lb. discharged per hr.	3688	7688	11319	
Boiler pressure gage	212.5	204.2	205.0	
Lb. discharged per hr. reduced to 200 lb. gage	3485	7541	11062	
Lb. discharged per min. reduced to 200 lb. gage	58.1	125.7	184.4	

3½-In. Flat Seat, Rounded Edge, Valve marked "B"

Lift of valve as set	0.02	0.05	0.08	
Total lift including yield of metal	0.0251	0.0551	0.0851	
Lb. discharged per hr.	3989	8482	12172	
Boiler pressure gage	209.2	202.7	199.5	
Lb. discharged per hr. reduced to 200 lb. gage	3825	8377	12201	
Lb. discharged per min. reduced to 200 lb. gage	63.7	139.6	203.4	

TABLE 2 SUMMARY OF RESULTS ON CROSBY INSPECTOR POP SAFETY VALVE

3-In. Flat Seat

Lift of valve as set	0.02	0.05	0.08	0.10
Lift including yielding of metal	0.0224	0.0524	0.0824	0.1024
Steam discharged per hr., lb.	1504	3473	4952	5998
Boiler pressure gage	111.8	109.8	106.3	105.9
Steam discharged per hr. reduced to 100 lb. gage.	1364	3200	4694	5705
Steam discharged per min. reduced to 100 lb. gage.	22.7	53.3	78.2	95.1

Lift of valve as set	0.02	0.05	0.08	0.10
Lift including yielding of metal	0.0244	0.0544	0.0844	0.1044
Steam discharged per hr., lb.	1984	4627	6854	8438
Boiler pressure gage	159.6	157.9	155.9	156.1
Steam discharged per hr. reduced to 150 lb. gage.	1875	4415	6617	8137
Steam discharged per min. reduced to 150 lb. gage.	31.2	73.6	110.3	135.6

3-In. Regular Bevel Seat

Lift of valve as set	0.02	0.05	0.08	0.10
Lift of valve including yielding of metal	0.0207	0.0507	0.0807	0.1007
Steam discharged per hr., lb.	879	2219	3500	4412
Boiler pressure gage	110.4	109.2	108.3	109.8
Steam discharged per hr. reduced to 100 lb. gage.	806	2054	3264	4065
Steam discharged per min. reduced to 100 lb. gage.	13.4	34.2	54.4	67.8

Lift of valve as set	0.02	0.05	0.08	0.10
Lift including yielding of metal	0.0210	0.0510	0.0810	0.1010
Steam discharged per hr., lb.	1313	3049	4670	5788
Boiler pressure gage	161.9	154.9	152.2	151.3
Steam discharged per hr. reduced to 150 lb. gage.	1225	2961	4608	5743
Steam discharged per min. reduced to 150 lb. gage.	20.4	49.4	76.8	95.7

3½-In. Regular Flat Seat

Lift of valve as set	0.02	0.05	0.08	0.10
Lift of valve including yielding of metal	0.0222	0.0522	0.0822	0.1022
Steam discharged per hr., lb.	1479	3636	5408	6760
Boiler pressure gage	105.2	99.2	98.1	102.1
Steam discharged per hr. reduced to 100 lb. gage.	1415	3661	5497	6638
Steam discharged per min. reduced to 100 lb. gage.	23.6	61.3	91.6	110.6

Lift of valve as set	0.02	0.05	0.08	0.10
Lift including yielding of metal	0.0232	0.0532	0.0832	0.1032
Steam discharged per hr., lb.	2070	5236	7772	9286
Boiler pressure gage	153.3	152.8	150.8	147.1
Steam discharged per hr. reduced to 150 lb. gage.	2029	5148	7734	9452
Steam discharged per min. reduced to 150 lb. gage.	33.8	85.8	128.9	157.5

Table 2—Continued

$3\frac{1}{2}$-In. Bevel Seat

Lift of valve as set	0.02	0.05	0.08	0.10
Lift including yielding of metal	0.0215	0.0515	0.0815	0.1015
Steam discharged per hr., lb	1058	2488	3878	4788
Boiler pressure gage	110.2	105.0	102.5	102.4
Steam discharged per hr. reduced to 100 lb. gage	972	2384	3795	4690
Steam discharged per min. reduced to 100 lb. gage	16.2	39.7	63.2	78.2
Lift of valve as set	0.02	0.05	0.08	0.10
Lift including yielding of metal	0.0222	0.0522	0.0822	0.1022
Steam discharged per hr., lb	1504	3518	5616	6746
Boiler pressure gage	152.2	151.1	154.9	147.4
Steam discharged per hr. reduced to 150 lb. gage	1484	3495	5454	6854
Steam discharged per min. reduced to 150 lb. gage	24.7	58.2	90.9	114.2

metals the same. In the case of the flat-seated inspector valves the body and spindle were of cast iron; in the case of the bevel-seated inspector valves the spindle was of composition, but the valve lift was adjusted by the disc-guide threaded below the seat. It will be seen by referring to the drawings that these combinations caused this difference of expansion to be reduced to a minimum.

TABLE 3 3-IN. MUFFLED LOCOMOTIVE POP SAFETY VALVE

Flat Seat with Rounded Edge, Valve Marked O. 0.08 In. Lift as Set, June 16, 1910

Time	Tank, Weight	Weight of Condensed Steam	Average Boiler Pressure (Gage)	Pressure Muffler (Gage)
10:24	232			
10:29	1120 275	888	204	0
10:34	1133 261	858	198	0
10:39	1131 266	870	204	0
10:44	1155 264	889	206	0
10:49	1105 265	841	197	0
10:54	1126	861	199	0

Total time, 30 min.; total steam, 5207 lb.; steam per hour, 10,414 lb.; average boiler gage 201.3 lb.; quality of steam (dry steam = 1) = 0.996.

12 In testing the valves the adjustments and settings were always made while the valve was hot, practically at the temperature of the valve during a test.

13 The additional lift due to the yielding of the metal because of the presence of steam pressure on the under side of the valve was determined in the case of each valve. The valve was supported by its flange in a testing machine and a load corresponding to 100, 150, or 200 lb. per sq. in. applied to the valve. The movement of the valve with reference to its seat was measured by a micrometer caliper. Different sets of readings on any one valve varied 0.0005 in. and the results are liable to be in error by this amount. It is probable that considering all of the errors in determining the total lift of the valve the result is good to about 0.001 in.

14 The steam was condensed in an Alberger bottom inflow surface condenser with a hot-well at the bottom. This condenser is used in connection with a 500-kw. Parsons turbine in the engineering laboratories at the Massachusetts Institute of Technology. Besides the regular drain to the hot-well there were additional drains of 4-in. pipe, one from each end of the condenser to the hot-well. The level in the hot-well varied about 1 in., which corresponds to about 9 lb. of steam.

15 Each weighing of a tank, empty or full, is good to $\frac{1}{2}$ lb. In the runs with 0.08 and 0.10 in. lifts, if all errors in weighing are assumed to be cumulative and an error of 1 in. in the level in the hot-well be also considered, the maximum error is 15 lb. The probable error is less but even this is a small percentage of the total.

16 In the case of the 0.02 in. lift, the maximum possible error due to all sources would be 10 lb. and for the very worst case this is $\frac{10}{586}$ or less than 2 per cent. The results of the calorimeter tests are good within 2 in the third decimal place.

17 The pressure readings by the boiler gage were taken at 1-minute intervals during most of the time, but occasionally more frequently when the pressure was varying. The gage was tested before and after each series of tests and was found correct.

ADDENDUM BY A. B. CARHART [1]

18 This series of tests of safety valves is notable in that the measurements of discharge are quantitative instead of merely com-

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[1] A. B. Carhart, Supt. Crosby Steam Gage & Valve Co., prepared additional data upon the type of valves tested and an abstract from this manuscript is herewith published.

parative and that the steam is measured by the condensation of the discharge, with determination by calorimeter of the moisture of the steam entering the valves. Some idea of the large condenser and boiler equipment required may be gained when the total discharge figures are compared with average conditions in ordinary work. And this tremendous rate of steam discharge was not for a few minutes only, but was maintained through 1-hour and $\frac{1}{2}$-hour periods of uniform flow.

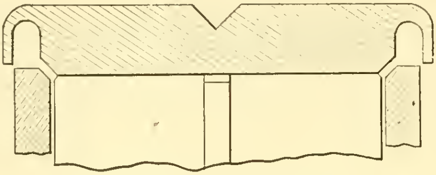


Fig. 8 Bevel-Seated Valve

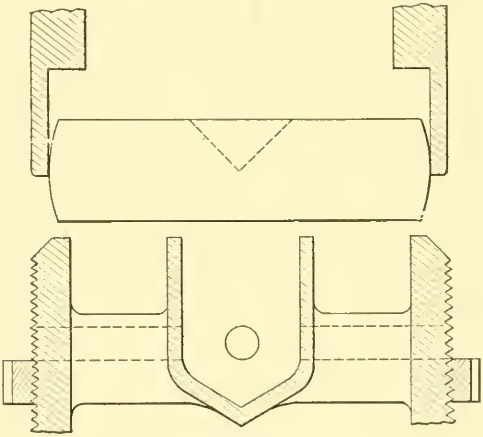


Fig. 9 Annular Valve

19 Every precaution was observed to avoid errors and all the readings were made by Professor Miller personally. The work was carried on at the Massachusetts Institute of Technology, because no commercial plant was found where the large steam supply could be uniformly maintained under absolute control. A part of the laboratory equipment there was utilized, but it was found necessary to erect a considerable amount of special apparatus and piping, and this preparation for the tests extended over nearly a year.

20 As the valves were adapted from ordinary commercial articles, altered in a few details to meet the requirements of convenient orifice regulation as planned by Professor Miller, it may be of importance to note what these peculiarities of construction were, and to supply some of the essential measurements that will be of interest to those who would like to make their own calculations of the areas of the valve passages and orifices.

21 Two of the iron-body valves were of the bevel-seated type, the contacting seat and disc faces forming a single steam-tight joint at an angle of 45 deg. to the vertical. The other two iron-body valves were of the annular type with two concentric seats in the horizontal plane, hence called flat-seated annular valves. The four locomotive valves were all of the flat-seated annular type, but in two of them the inner edge of the larger seat face was made slightly rounded, differing in this detail from the other two similar locomotive valves with which they were to be compared. The effect of this slight change of orifice form and proportion in the locomotive valve seats in greatly increasing the steam discharge is clearly demonstrated.

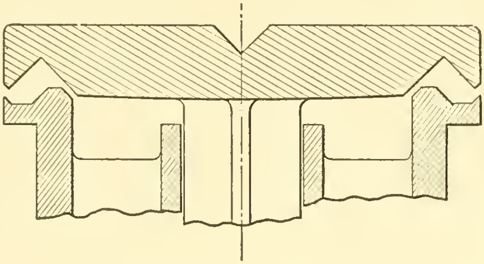


FIG. 10 TYPE OF BEVEL-SEATED VALVE USED IN TESTS

22 Pop safety valves were invented about 60 years ago, and about 30 years later were perfected in this country and went into general use. Broadly, the invention consists of an addition to the disc of the safety valve, so designed that when the valve is closed such addition is excluded from the action of the steam, but when the valve opens the outflowing steam acts upon it and with the initial force causes the valve disc suddenly to rise higher and the spring to be more compressed than it would be with a force due to the steam pressure upon the original area only; thus there is afforded a prompt,

full-open passage at the seat through which the maximum quantity of steam will flow at once and give relief to the boiler.

23 The bevel-seated valves (Fig. 8) generally have this additional area at the periphery of the disc, outside of the seat, where it forms a chamber with more or less contracted outlet at the extreme lip of the valve, through which all the steam must pass after escaping over the seat before it reaches the open air. As the seat is formed at an angle of 45 deg. to the vertical, the passage between the seat and disc faces when the valve opens is diagonally upward, and what is called the lip of the valve is so related to this seat that the steam is forced to impinge directly upon it before being deflected downward toward the bottom of the chamber where it reacts, the effect of the impact upon the lip of the valve being increased by the expansive force of the steam acting in the lip chamber on account of the partial and momentary confinement before it passes into the open air. This force is regulated in various ways. Sometimes openings are made through the lip or in the floor of the chamber, through which the steam escapes and so reduces the pressure within the lip chamber that the valve disc will not lift too high. Most valves of this kind have a threaded ring surrounding the chamber, providing a micrometer adjustment by means of which the opening at the lip may be made wider or narrower at will. The ring sometimes slightly overlaps the disc at its periphery until the valve has lifted an appreciable amount.

24 Annular valves (Fig. 9) have the additional area located at the center of the disc and within the outer seat. This area is excluded from the action of the steam when the valve is closed, by means of an inner seat, but acted upon directly by the steam when the valve opens. The disc is simply a flat cover for the valve base and has two concentric seats in the same horizontal plane. The central area of the disc, which is not exposed to the steam when the valve is closed, covers a well which communicates to the outer air through four hollow arms radiating from it out through the sides of the valve body. When the valve opens, the steam is discharged directly across the outer flat seat, and there is also a separate additional flow over the inner seat into the central well and out through the four hollow arms. The openings through these arms are controlled by a sleeve, threaded on the valve body, so that it may be turned upward or downward as desired. If it should close the open ends of the hollow arms, preventing the escape of the steam through

the central well, the reactionary effect upon the disc to lift it against the spring would be greater than if the openings from the well were unobstructed; and by locating the sleeve at intermediate points the lift of the valve can be varied.

25 While both styles of valves are efficient, it will be noted that in the bevel-seated type all of the steam passes over the single seat and through the additional regulating chamber at the lip of the valve, and in some cases through a constricted passage at the periphery of the lip; while in the annular valve the steam for the relief of the boiler pressure passes directly through the outer seats without any obstruction whatever, unaffected by any regulation of the by-passed steam through the center that may be necessary. Also, for a given lift of valve, the area of opening through a flat-seated valve is nearly $1\frac{1}{2}$ times that through a valve with bevel seats.

26 In bevel-seated valves the disc is ordinarily guided vertically so that it will return properly to its seat when the valve closes, by means of four or more radiating wings or vanes depending from the face of the disc in the steam space and bearing against the sides of the inlet or throat of the valve (Fig. 8). In the bevel-seated valves tested by Professor Miller, the disc was mushroom-shaped, the guide being small in diameter and acting in an open hub supported in the steam space by arms extending from the sides (Fig. 10). But in the annular valve there are no guides or wings attached to the disc, which is simply a flat member having the truncated form of the central zone of a sphere. This is placed in a cylindrical chamber outside and above the steam space, and there it lifts or moves freely as acted upon by the steam against its lower face and by the opposed spring which presses upon it at its center. The contact between the chamber and the spherical part of the disc is the least possible, which permits universal movement of the disc without possibility of cocking or sticking, and yet insures that the disc will return accurately upon its seats when the valve closes.

27 In the two of the iron-body valves that were fitted with these annular seats, and in two of the locomotive valves, the escaping steam was compelled to make a sharp right-angled turn in passing out over the inner edge of the main discharge seat (Fig. 11). This had been the construction for many years, as the concession to more simple manufacturing operations. It was proposed by Professor Miller to round this corner slightly, as indicated at A' in Fig. 12, at the junction of the side wall of the inlet or throat of the valve with

the main outer seat, for he believed that this would permit a larger flow of steam. Therefore, two other locomotive valves were submitted to test, exactly like the first in all respects except that this edge was rounded, but only to the small extent that the castings would permit without change in patterns. The valves with the angular corner are referred to in the tests as having the "square edge," while the valves with the rounded corner are designated as having the "rounded edge." Fig 4 shows the later form of these valves with shape of inlet passage modified.

28 The locomotive valves were cast with flanged bases, similar in size to the iron-body valves, to suit the pipe connections to which they were attached during the tests. The designating letters, *J*, *O*, *A*, and *B*, were stamped upon the locomotive valves before the tests, simply as a convenient means of identification.

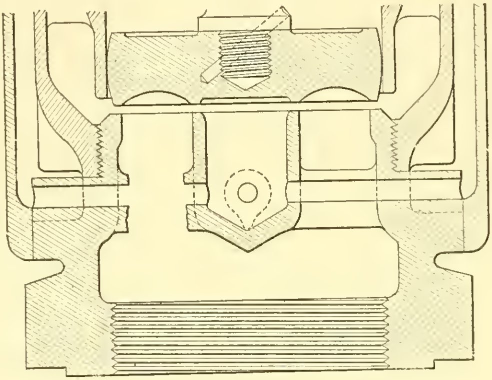


Fig. 11 Sectional View of Annular Valve

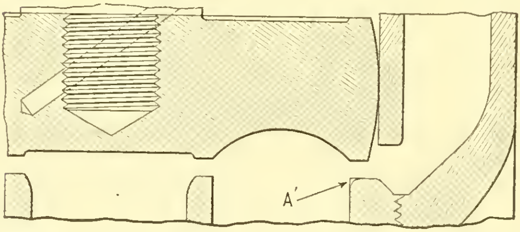


Fig. 12 Annular Valve showing Rounded Corner of Valve Seat

29 In both bevel-seated valves, the total width of the seat-face *CBE* (Figs. 13 and 14) was 0.088 in., and the vertical distance *m* between the planes of the lower edge of the seat face at *C* and

the outer edge of the seat face at *E* measured 0.062 in., in both the 3-in. and $3\frac{1}{2}$-in. valves; therefore when the valve disc was lifted 0.02 in. and 0.05 in., in the tests, the condition is represented by Fig. 13, and when the disc was lifted 0.08 and 0.10 in., the lower face of the disc at *A* was above the plane of the outer edge of the seat face at *E* and the condition is represented by Fig. 14. It will be seen of course that the entrance to the diagonal passage through the seat when the valve is open is measured on the perpendicular line let fall from *A* to the seat face at *B*, and this has the mean diameter *d*, which is greater by the distance $\frac{\text{lift}}{2}$ than the diameter *D*, which measures the area of the disc that is under pressure when the valve is closed.

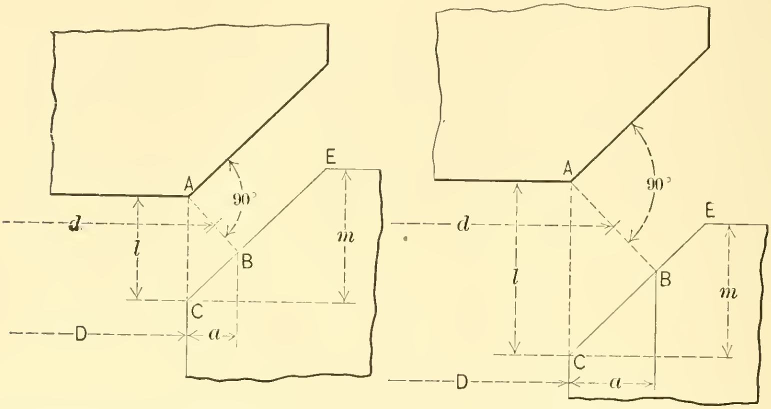
30 It is apparent that calculating the area of the discharge passage upon the greater diameter *d* instead of the distance *D* gives some theoretical advantage in this style of valve, yet the total quantity of steam discharged is nevertheless not as great as in the case of the flat-seated valves, in which the free, open passage through the outer seat is measured by the normal circumference of the inner edge of the seat having the diameter *D*, multiplied by the actual vertical lift of the disc.

31 In the annular valves, the area of the opening into the central well over the inner seat is considerably greater than the outlet area from the well through the four hollow regulating arms, even when these passages are left full-open; for the smaller edge of the inner seat face leading to the central well is 1 1/16 in. in diameter in the 3-in. valve, giving a circumference of 3.33 in., and in the $3\frac{1}{2}$-in. valve the smaller edge of this inner seat over which the steam passes to the central well is $1\frac{1}{4}$ in. in diameter, giving a circumference of 3.92 in.; so that, at 0.08 in. lift for example, the area of the entrance to the well is 0.26 sq. in. in the 3-in. valve and 0.31 sq. in. in the $3\frac{1}{2}$-in. valve. Compared with this, the hollow arms, leading from the central well, are $\frac{1}{4}$ in. in diameter in the 3-in. valve and 9/32 in. in the $3\frac{1}{2}$-in. valve, the four arms giving an additional possible total area of 0.196 sq. in. to be added to the main discharge in the 3-in. valve, and 0.248 sq. in. additional in the $3\frac{1}{2}$-in. valve.

32 Measurements of the pressure in the central well chamber, however, made by connecting a pressure gage to it by means of a separate pipe, show that the pressure existing there when the valve is blowing is appreciably less than the indicated boiler pressure. The

total effective discharge area to be credited to these auxiliary outlets through the central well may therefore be taken as from 4/10 to 8/10 of their nominal measured area just given.

33 In calculating the total effective discharge area of these annular valves, first multiply the smaller circumference of the outer seat by the full vertical lift of the disc and add to this a reduced percentage of the area of the four arms or of the portion of their exit ends not covered by the regulating gate. The effective pressure in these restricted passages is of course considerably reduced, and depends more or less upon the amount of the opening at the seat leading into this central chamber and the freedom of flow into it, for when the disc is lifted from its seat only 0.02 in., there must be an appreciable restriction or wire-drawing of the steam flowing into the central well, and therefore it seems fair to take the value of the discharge area of the hollow arms under these conditions as only 40 per cent of their measured area, increasing to 70 per cent when the lift is 0.05 in. and 80 per cent for the normal lifts of 0.08 and 0.10 in. But these approximations are not important and do not greatly affect the results, for the function of this small by-passed flow of steam is principally to regulate the lift of the disc, and the quantity of discharged steam through the central passages is only incidental and additional, and for all practical purposes these estimated values may be taken as fairly conservative.



Figs. 13 and 14 Diagrams showing Discharge Area of Bevel-Seated Valves

34 The width of the seat face on the casting of the base of the

annular valve is approximately 3/16 in. for the outer seat and $\frac{1}{8}$ in. for the inner seat, and the faces on the disc fairly coincide with these when the valve is closed, though the actual width of the contacting faces may be better assumed as about $\frac{1}{8}$ in. for the outer seat and 3/32 in. for the inner seat leading to the central well. The formula for calculating the effective discharge area of the annular valve is:

$$\begin{aligned}\text{Discharge area} &= (\text{circumference of outer seat} \times \text{lift}) \\ &\quad + 4\times (\text{net effective area through each arm}) \\ &= \pi Dl + 0.8 \times \pi(\text{diameter of arm})^2\end{aligned}$$

35 In the bevel-seated valves tested by Professor Miller, the area of the discharge passage over the valve seat may be calculated by the well-known formula, which is made clear by reference to Figs. 13 and 14 illustrating the two cases involved, one where the disc at *A* does not lift higher than the vertical distance *m* between the inner and outer edges *C* and *E* of the seat face, and the other where the lower face of the disc at *A* rises above the horizontal plane of the outer edge *E* of the seat face.

$$AB = l \sin 45 \text{ deg.} = 0.707l$$

$$d = D + \left(2\times\frac{a}{2}\right) = D + \frac{l}{2}$$

$$\text{Seat circumference} = \pi D$$

$$\text{Orifice circumference} = \pi\left(D+\frac{l}{2}\right)$$

$$\begin{aligned}\text{Discharge area} &= (AB)\pi\left(D+\frac{l}{2}\right) \\ &= (0.707l)\pi\left(D+\frac{l}{2}\right) \\ &= 0.707\pi Dl + \frac{0.707\pi l^2}{2} \\ &= 2.22Dl + 1.11l^2\end{aligned}$$

This form of the equation gives results about $1\frac{1}{4}$ per cent larger than the usual approximation

$$\text{Discharge area} = 0.707\pi Dl$$

36 In both types of valves concerned in these tests, the lower end of the inlet connection measures appreciably larger than the actual diameter at the valve seat, and the net area of the unobstructed passage leading up to the edge of the valve seat where the steam escapes is several times greater than the largest possible area through the seat for steam discharge that is intended to be opened in the ordinary operation of the valves. In the case of the annular valves the area

of the inlet passages is approximately three times that of the discharge passages and in the case of the bevel-seated valves it is from three to four times, assuming in each case that the valve lift is 0.1 in.

37 The accompanying chart, Fig. 15, shows the relative areas in square inches of the narrowest parts of the passages and chambers through which the steam discharged, in the locomotive valves, after passing the valve seat; and the progressive increase explains why the valves were satisfactorily muffled without any retarding effect upon the escaping steam, and why, as noted by Professor Miller, no back pressure could be detected.

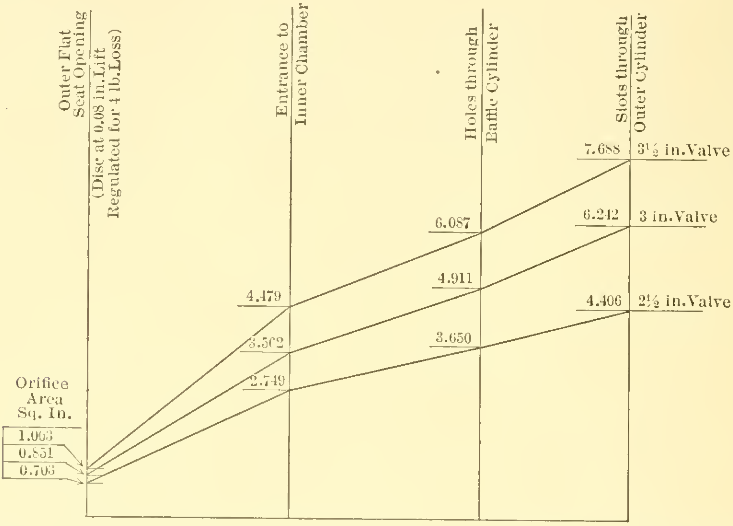


Fig. 15 Diagrams showing Passage Area at Different Points in the Locomotive Valves

38 When any safety valve is closed steam-tight, the actual line of contact between the disc face and seat face is a sinuous line without appreciable width, which at points approaches the inner or outer edge of the seat face as happens. Therefore the exposed area of the valve disc, under pressure when the valve is closed, is never exactly the same as the theoretical area calculated by the rated diameter of the valve seat. But for all practical purposes it is nearly so and the diameter of the inner edge of the seat is generally taken as the measure of the disc area.

39 This method of measurement shows a total of 7.07 sq. in.

area of the disc under pressure in the 3-in. bevel-seated valve, when the valve is closed, and 9.62 sq. in. in the 3½-in. valve. In the flat-seated annular valve the net area of the annular face under pressure is 5.79 sq. in. for the 3-in. valve and 7.85 sq. in. for the 3½-in. valve. To obtain these values the areas enclosed within the central seats were deducted. In the 3-in. valve the diameter of the central seat is 1 9/32 in. in diameter and in the 3½-in. valve 1½ in.

40 Multiplying any of these effective areas by the boiler pressure will give the load upon the disc at the moment before the valve opens, which load must be sustained by the valve spring. This is calculated to be of the proper proportions to hold the valve to its seat until the opening pressure is reached and after permitting a full opening of the valve by the lifting of the disc against the spring pressure must return the disc again to its seat and close the valve when the predetermined amount of decrease in boiler pressure has been attained. If the total area of the disc be taken into account, after the valve opens, it is easy to determine the mean pressure of the discharging flow effective to raise the disc, until the reaction of the spring is sufficient to close the valve against the reduced pressure upon the whole face of the valve disc.

41 Assuming, for example, a compression of the spring of 0.50 in. from its free length to exert a load upon the disc equal to the steam pressure of 100 lb. per sq. in., then a lift of the disc of 0.10 in. further would increase the tension of the spring and increase the reactionary load 1/5 more than when the valve is closed. Therefore the discharging steam acting by impact and expansion against the whole area of the disc face when the valve is blowing would have to sustain momentarily a maximum load 20 per cent greater than was exerted by the steam at 100 lb. per sq. in. upon the initial area of the disc when the valve was closed, although after the steam has passed out over the valve seat into the lip chamber or into the central well it is of course at much lower pressure and has increased considerably in volume.

42 The extreme diameter of the outer edge of the lip of the disc in the 3-in. bevel-seated valve may be taken as 4⅛ in. when the valve is open, and 4¾ in. in the 3½-in. valve. The face of the outer seat of the disc in the annular valve has an appreciable width, making the extreme diameter of the disc acted upon by the steam when the valve is open 3 3/16 in. in the 3-in. valves and 3¾ in. in the 3½-in. valves.

43 Although the discharge passage over the outer flat seat of the annular valve is nearly $1\frac{1}{2}$ times as large as is possible in any bevel-seated valve of the same diameter-size and lift, the area of the valve disc exposed to the steam when the valve is closed is however only about four-fifths of the total area of the disc, by reason of the central portion within the inner seat circle being shut off from the boiler pressure until the valve opens. This causes less load upon the disc, much less strain and pounding of the valve in seating and less necessary size and spring trouble, than in a bevel-seated valve of the same rated size or seat diameter. When the valve is closed, as the steam pressure of the boiler acts only upon the annulus, or the area between the outer and inner seats, the spring is required only to meet this steam pressure. Therefore the spring has to exert less absolute force than if it held the disc to its seat against the steam acting upon the whole area of the disc. The universal action of the disc due to its spherical edge within the cylinder provides against any binding effect from undue eccentricity of the spring, for all springs in compression necessarily shorten with a torsional movement and side-thrust transmitted to the disc-guides.

44 There is a decided advantage, therefore, in reducing the necessary movement of the spring in its compression and distortion when the valve opens to the minimum amount possible, while yet attaining the required volume of steam discharge.

COMMERCIAL APPLICATION OF THE TURBINE TURBO-COMPRESSOR

By Richard H. Rice, Published in The Journal for March, 1911

ABSTRACT OF PAPER

The paper describes a compressor unit for blast-furnace work consisting of a four-stage Curtis steam turbine direct-connected to a six-stage centrifugal compressor. This was built and installed at Oxford Furnace, N. J., by the General Electric Company, and is the first of this type of apparatus to be made in this country. It is governed automatically by mechanism which depends for its action upon a change in the rate of air flow, by which means the speed of the turbine is varied as required. The governor regulates the volume of air delivered per minute so as to keep the rate of discharge constant at the value determined by the furnace superintendent. It is found that on account of the steadiness of operation and more uniform conditions the output of the furnace has been increased and it is concluded that, considering all the factors, the centrifugal compressor as a blowing apparatus can be operated at a lower net cost than any other means for blowing furnaces. The paper contains data upon sizes and capacity of the apparatus with diagrams showing the characteristics of its performance.

DISCUSSION

E. D. Dreyfus (written). The comparison of the ultimate economies of the reciprocating gas-engine blowing engine, and the high-pressure turbine-driven compressor is most vital. But we must not allow ourselves to be guided by any abstract quantities, and in order to obtain a comprehensive idea of their relative commercial value, we must study a wide range of sizes and conditions. The relation of single small sets of the two types will in all probability be reversed when installations of a great many large units are compared. Isolated data should invariably be treated guardedly, more particularly where an appreciable variation in conditions may exist. There is one thing which occurs to my mind especially and that is

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Presented at the Spring Meeting, Pittsburgh 1911, of The American Society of Mechanical Engineers. All discussion is subject to revision.

the large gas-engine blower will have but little showing in the extensions of any present mills where it will be practical to install and operate low-pressure turbine-driven compressors in connection with older steam-engine-driven tubs. The investment value of this earlier apparatus will thus be preserved and at the same time its economy when operating in connection with the low-pressure turbine will be greatly bettered. Another point of economic consideration is the coördinating of the low-pressure turbine with the gas plant, whereby the position of the gas engine may be materially advanced, an analysis of which was contributed by the writer to Power, April 11, 1911.

J. E. Johnson, Jr. The efficacy of the control of the volume of air blown is the question which will arise in the mind of every practical furnace man as soon as he gives this subject consideration. Changes in quantity of air as small as 1 or 2 per cent are frequently made in the quantity of blast delivered to the furnace as one of the means of controlling its operation and this makes it obvious that exact control is a very necessary feature of any blast-furnace blowing apparatus.

I had the pleasure of seeing the installation of the turbo-blower at the Port Henry plant of the Northern Iron Company about a year ago, and the simplicity of the governor is certainly admirable, but is a feature not exactly easy of comprehension to a man without a thorough mechanical training, and a prejudice against these machines is likely to exist in the minds of many furnace men.

It is a well accepted fact that the efficiency of the turbine is far higher at low pressures than it is at high, while on the other hand it is equally well known that for high pressures only, the reciprocating engine has a considerable advantage over the turbine. The result is that the most economical form of steam-driven apparatus is a combined unit in which the steam expands down to about atmospheric pressure in a good reciprocating engine, and is then delivered to a turbine on its way to the condensers. The very remarkable results obtained with this combination by Mr. Stott at the Interborough plant in New York have given, in the opinion of many, a decided check to the development of the gas engine.

In a similar way it has been known for years that for very low pressures the centrifugal blower, of which the turbo-blower is simply a development, is more economical than a piston blower: On the other hand, for higher pressures the piston compressor is undoubtedly to be preferred, particularly in blast furnace work, on account of its operating as a meter as well as a compressor of the highest efficiency.

A condition of piston blowing engine design is that the air cylinder must be large enough for the greatest volume to be handled, and strong enough for the highest pressures attained, with the result of enormous size and very massive and expensive construction in modern blowing machinery.

In spite of their high cost it is notorious among operating men that really reliable blowing engines are exceedingly scarce. The problem of the valves is in itself one of great difficulty. It is almost impossible to get an air inlet valve with sufficient area to allow the cylinder to fill absolutely without heavy loss by suction, and at the same time one quick enough to give correct results at the speeds required of modern engines.

The turbo-blower, on the other hand, suffers from the disability that it must have stages enough to blow the highest pressure ever required, although this high pressure will not, in ordinary operation, be required one per cent of the time, the normal pressure being perhaps only half as great.

If, therefore, we make a turbo-blower to deliver air of a certain nearly constant, moderate pressure, and a blowing cylinder of comparatively small size, strong enough to deliver air to the desired maximum pressure, we shall have bettered the conditions of operation of both types of apparatus, increasing their efficiency and reducing their cost. In other words, the turbo-blower and reciprocating-compressor combined are more efficient than either apparatus alone, exactly as the engine-turbine combination is more economical in the consumption of steam.

For the best and cheapest blowing engine, therefore, we should have a combination of these two units, a turbine-driven turbo-blower, delivering air partly compressed to the compressing end of a steam-driven blowing engine, the steam from the cylinder of this engine driving the turbine before passing to the condenser.

It may be objected that this is a complicated unit, but this is not the case. Most large modern furnaces require three large reciprocating blowing engines of the best type to operate them. These are, in good modern usage, disconnected compounds—a high-pressure steam cylinder on one engine and a low-pressure on the next, etc.

A turbo-blower supplying air to two of these, compressed to 8 lb., would enable them to deliver as much air as three engines drawing air from the atmosphere, and the efficiencies which are guaranteed in the use of exhaust steam by the builders, combined with the guaranteed efficiency of the turbo-compressor, indicate that this can be done at a decided saving in first cost and with an efficiency certainly no lower and probably higher than that of either unit alone. This does not make any allowance for the possibilities of spray intercooling between the turbo-compressor and the reciprocating compressors, which, in ordinary practice, would be good for about 4 per cent additional saving at a very low cost.

The advantage of maintenance as compared with reciprocating engines, is undoubtedly with the turbo. At the same time the magnitude of the alternations of stress in the reciprocating engines is greatly reduced by delivering to them partly compressed air, and the problem presented by their inlet valve gear, which has given so many bad hours to both furnace men and engine designers, is practically eliminated by delivering to them denser air under pressure.

The governing of such a combined unit is extremely simple. The ordinary governor on the engine unit does all that is necessary and no governor other than one to prevent racing is necessary on the turbine. The steam supply of the engine passes directly to the turbine. As long as all conditions remain constant the speed of the turbine will be unchanged, but if the pressure required by the furnace increases a little, more steam is admitted to the engine by its governor, and this increase in quantity speeds up the turbine to a slight extent and so causes it to deliver air compressed to a slightly higher pressure.

This increase automatically compensates for any small lag due to the greater load on the engine and for the lower volumetric efficiency of the piston blowing engine at higher pressure as compared with low.

If, on the other hand, the speed of the piston engine is deliberately increased to deliver more wind, the greater supply of steam to the turbine will enable it to deliver a proportionately greater quantity of air at virtually the same pressure. Of course, some hand control will be applied to the turbine to enable the receiver pressures to be adjusted to the best conditions, but once this is done other changes will seldom be required.

For these reasons I believe that the steam-driven blowing plant of the future should consist of a turbine-turbo, piston-engine, piston-compressor combination.

This combination will have its greatest field in applications to existing plants where, as is so often the case, the existing blowing engine, while old, is by no means worthy of the scrap-heap, but is unable to deliver quite the pressure or quite the volume demanded by modern conditions. In such a case the introduction of a turbine-turbo, taking steam from the engine and supplying pre-compressed air to it, will use what is now waste energy in the steam, and apply it in such a way as to increase both the capacity and the permissible pressure of the existing blowing cylinder.

A further advantage which the turbo has as the primary machine is that of an inlet free from pulsations. These are much more serious in inlet than in outlet, for the reason that the volume and velocity of the air are so much greater.

One of the serious problems which had to be overcome in the application of the dry blast was the construction of cooling chambers whose walls would not be thrown down by the pulsations produced by the piston compressor on the incoming air. The smooth inlet of the turbo will eliminate entirely difficulties arising from this source.

The necessity of massiveness both in stationary and in reciprocating parts, and the conditions of operating the air valves, have limited the best sizes of blowing engine so that these are not increasing in size. In fact, those now being built are commonly no larger than some constructed ten or twelve years ago.

The turbo-blower, on the other hand, lends itself admirably to enormous capacities in the same way that the turbine is commonly built for certain classes of service in sizes that have never been approached in reciprocating engines. For this reason it will not only be possible but advisable to install at large plants one turbo to supply several reciprocating engines, all of which, of course, will exhaust to it. This will contribute still more to low first cost, small space requirements and small maintenance charges.

I wish to express in conclusion my conviction that the introduction of the turbo-compressor marks the beginning of a better era for the mechanical equipment of blast furnaces, but that its best and easiest application will be in conjunction with rather than in supplanting piston blowing engines.

R. N. Ehrhart.[1] The Westinghouse Machine Company have for some years been experimenting with centrifugal air compressors at their East Pittsburgh works, and as a result have developed a type of blower possessing features particularly adapting it to certain classes of work.

As the single-stage blower is the basic element of the multi-stage blower, analyses of the primary considerations should be applied to the single part or stage which is duplicated in certain instances to make the multi-stage outfit. Any features pertaining to the generic element pertain to the whole, so that studies of the single-stage blower are more enlightening from a practical and educational standpoint. The following facts were brought out in the development of the elements of centrifugal compressors:

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[1] The Westinghouse Machine Company, East Pittsburgh, Pa.

Centrifugal compressors having diffusion vanes in the part of the casing receiving the air from the rotating element have as an inherent characteristic the pressure curve shown in broken line in Fig. 7. (In this discussion, the writer calls this the forced-diffusion type of blower.) The efficiency also has the characteristic as shown in Fig. 7; that is, a maximum efficiency of approximately 74 per cent at rated volume and approximately 60 per cent at one-half volumetric rating. These results were obtained by extensive experimenting at East Pittsburgh and are approximately verified by Fig. 2.

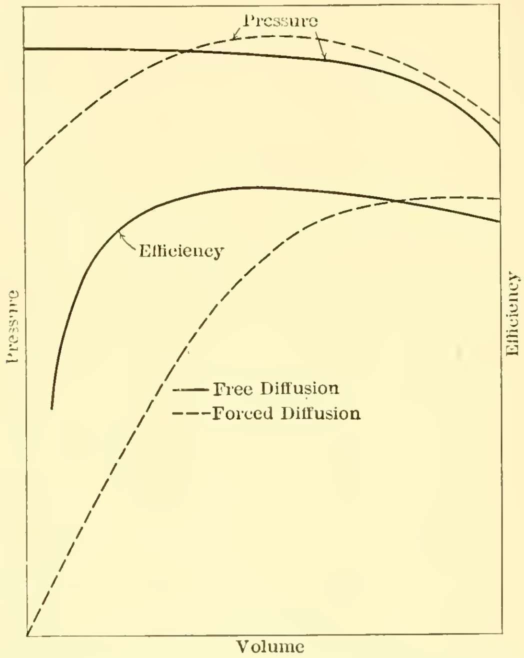

Fig. 7 Comparison of Blowers with Free and Forced Diffusion

For the industrial application of constant-speed blowers, it was early realized by the Westinghouse Machine Company that the pressure characteristic as shown by the broken line (forced diffusion) in Fig. 7 was unsuitable, as reference to Fig. 8 clearly shows.

The forced-diffusion type of blower has a pressure characteristic with a well defined hump; that is, the pressure rises as the volume delivered increases to a certain point, and the pressure then rapidly falls off. In other words, for a given pressure there are two definite volumes that may be delivered. Referring to the lower set of curves, Fig. 8, at the pressure represented by the horizontal line there may be two volumetric deliveries, *B* and *D*. It is perfectly evident that blowers of the forced-diffusion type will be unsatisfactory for parallel operation, unless equipped with a complicated governing mechanism, since momentary disturbances may cause fluctuating line pressures and if the disturbance has a magnitude measured from the horizontal line to the peak of the pressure characteristic, the volumetric delivery may vary from *B* to *D*. This latter possibility will in turn accentuate any line disturbances, causing still greater variation or fluctuation in volumetric delivery, assuredly at the sacrifice of efficiency.

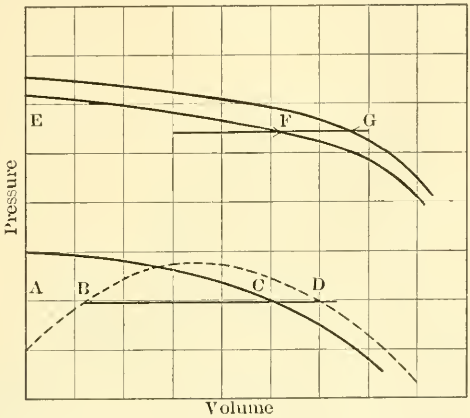

Fig. 8 Characteristics Required for Parallel Operation of Blowers

In the case of parallel operation of alternators, we require a gradual drop in speed from no load to full load for stability. In the parallel operation of blowers, we should have the analogy of a gradual drop in pressure from no delivery to full delivery.

Blowers having this characteristic will work perfectly in parallel. Referring to Fig. 8, the upper pair of lines, shows the sharing of the load. One blower at the pressure represented by the horizontal line will have a volumetric delivery *EF*, the other one a volumetric delivery *EG*, and fluctuations of pressure over a wide range will still insure relatively equal division of the load.

Positive blowers have the drooping characteristic at constant volume, and it is seen that if this is superimposed on the forced-diffusion pressure characteristic, successful parallel operation cannot be had.

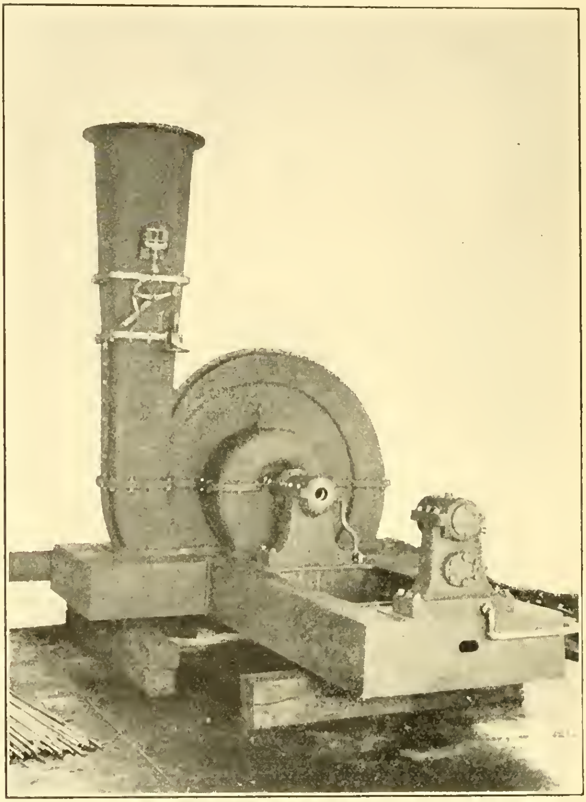

FIG. 9 A 600-H.P. BLOWER OF FREE-DIFFUSION TYPE

Of course, by resort to complicated speed-control mechanisms on what might be a constant-speed outfit, the forced-diffusion type of blower can be made to give the drooping characteristic.

Thorough experimenting has shown that by suitably constructing the stationary and rotating parts of the blower, a drooping pressure characteristic can be obtained; that is, the pressure at no delivery is a maximum, and it gradually drops off to normal at normal rating. This characteristic is shown in full line in Fig. 7. It has also been found that the efficiency at fractional deliveries was wonderfully improved. As a matter of fact, the diffusion vanes in the forced-diffusion type of blower are a positive detriment at fractional loads, since their angle and shape can be made only to suit one discharge rate.

For example, in a blower with radial vanes, the air leaves the rotor at an angle of about 14 deg. with the tangent at normal delivery. At 50 per cent of normal delivery the angle is about 7 deg.; at 10 per cent of normal delivery it is about 1½ deg. It is apparent that if the receiving ends of the diffusion vanes are set for normal delivery, they are 12½ deg. from the correct position for 10 per cent of normal delivery, or 7 deg. from correct position for 50 per cent normal delivery.

Experiments at East Pittsburgh show that free spiral diffusion can be obtained with substantially the same conversion efficiency at 25 per cent normal delivery as at full normal delivery. The discharge areas and contour of vanes and receiving sides of the spiral whirl chamber must coincide exactly with the dimensions as fixed by experiments and calculations. Relatively small variations from proper shapes cause loss of velocity conversion efficiency.

Fig. 7 shows comparative tests of the two types of blowers made at the Westinghouse works, the splendid pressure characteristic and superior efficiency of the free-diffusion type at fractional loads being clearly illustrated.

The free-diffusion type of blower does not have the pulsation characteristic that the forced-diffusion type has. This is due to the total absence of diffusion vanes, so that free spiralic diffusion can adapt itself to any volumetric delivery. The pulsations as described by Mr. Rice in Pars. 22 to 25 (Fig. 4), would seem to be of such magnitude (approximately 9 to 10.5 lb.) as to make parallel operations difficult when they are in evidence. The method used at Oxford to get over the pulsating effect, that is, throttling, may be successful when applied to high-pressure blowers, but when applied to blowers of low pressure the loss of a few inches of water pressure by throttling could not be considered as it would represent too great a proportionate loss in efficiency.

A 600-h.p. blower of the free-diffusion type has just been put into operation at Great Falls, Mont. The pressure characteristic corresponding to that given in Fig. 7 is attained with a constant speed, and no governing devices to change the motor speed are necessary. The outfit is driven by a 750-h.p. synchronous, 60-cycle motor. Fig. 9 shows the blower by itself.

C. G. de Laval. The development of the turbo-compressor in this country is of recent origin and without question the combination of the steam turbine and turbo-compressor produces an ideal unit. It appears, however, that its field will rather be the compressing of large than of small volumes. Not long ago it was considered unsuitable for anything except exceedingly low pressure, such as ordinary blowing work. Today we find turbo-compressors in use abroad for 150 lb. equal in thermal and mechanical efficiency to reciprocating compressors.

It is well to consider the distinction between a blower and a compressor, and it appears to the writer that the machine described is not a compressor, but a turbo-blower. Both may be of the same design, but this is not essential. The machine described is a multistage blower or fan, and apparently has no rubbing surfaces. The rotating surfaces revolve freely with ample clearances.

In turbo-compressors manufactured by Pokorny and Wittekind, Brown-Boveri & Company, Esches, Wyss, Sulzer Brothers, Rateau and others, the machines are made up in multiple cylinders according to volume and pressures. The general principle consists of high-speed impellers incased in a cylindrical chamber, properly cooled radially and axially. These impellers draw in and discharge the air the same as a centrifugal pump impeller, turning the velocity into potential energy in the form of air pressure.

It does not appear necessary to use six stages arranged in series for so low a pressure as 10 to 20 lb., and if the compressor end were divided into separate cylinders or casings, each cylinder or casing containing one or more impellers, and the diameter of the impeller and its casing were reduced in the second or third, the number of stages required would be less than that used by the author, provided also that proper cooling was effected radially as well as axially.

A turbo-blowing engine built on the Rateau type for 12,300 cu. ft. of free air per minute down to 6000 cu. ft. for a pressure of from 8 to 13 lb., speed 3400 to 3900, requires three stages only as against six stages of the one described in the paper. This Rateau multi-blower has single entrance impellers, leading the discharge from one wheel into the eye of the other through special channel castings. For pressures of 80 to 150 lb. it is not necessary, if it is properly constructed, to use more than 10 to 15 stages, and for lower blowing pressures, 10 to 20 lb., 3 stages, and still maintain an isothermal efficiency of 70 per cent. Such compressors will have a weight about one-quarter of that of a reciprocating outfit.

It has been shown through their use in Europe that turbo-compressors with capacities of 6000 cu. ft. per min. and above have from 70 to 80 per cent efficiency, and those of from 3000 to 6000 cu. ft. per min., 65 to 70 per cent efficiency, and that these efficiencies decrease below 50 per cent at $\frac{1}{2}$ to $\frac{1}{4}$ load. The application of turbo-compressors should be for volumes from 3000 cu. ft. per min. and up.

It is usual to fit compressors with an automatic outlet valve in order to prevent any detrimental pulsation of air at partial capacities, so that the capacity can be kept above the minimum. To prevent an increase of the capacity over the maximum, an automatic valve is installed in the suction.

The use of a turbo-blower in connection with existing reciprocating compressors has been carried out lately in England. The existing compressor was coupled up to a steam turbine turbo-blower, whereby the low-pressure steam cylinder of the reciprocating air compressor exhausted into the steam turbine, and the turbo-blower took the air at atmospheric pressure, compressing it and discharging it into the reciprocating compressor cylinders where it is compressed to 60 lb. pressure.

This combination of turbo and piston-compressor doubled the capacity and gave a net gain of 17 per cent over that which would have been secured had an additional reciprocating compressor been put in. In addition to this it saved the extra cost of a new building on account of the small space it occupied and increased the over-all efficiency, as it utilized the exhaust steam.

It may not be out of order to add the following as characteristics of turbo-blowers and compressors:

a Steady non-pulsating currents when fitted with proper control apparatus.

b Smaller weight and space required, reduction of foundations and handling.

c Absence of reciprocating parts, valves and packings.

d Smaller attention and maintenance.

e Reduction of oil consumption and supply.

f Continuous and steady delivery of air, flexibility of operation, automatic arrangement.

g Utilization of exhaust steam from any reciprocating engine to run the low-pressure turbine operating the blower or compressor.

h Efficiency of the machine, comparing favorably with the best reciprocating compressors.

i Adaptability for cupolas, brass furnaces, converter, operating pneumatic tools, etc.

j Adaptability to operation and furnishing of illuminating gas to mains.

Julian Kennedy[1] said he did not know much either about gas engines or turbines, but he had been doing a little figuring. On a basis of $116 per kw. for gas-engine installations and $60 for steam-turbine installations, he assumed that 20 per cent was a fair amortization charge for up-keep and capitalization for the gas machinery, and 15 per cent for the steam machinery: the investment cost, therefore, for gas machinery would be $23.30 per year, and for the steam machinery $9 per year.

Assuming 7200 hours per year and 2 lb. of coal per kw-hr. at $1.80 per net ton, the cost of coal per kw-hr. would be $0.18, or less than the additional charge of up-keep and capitalization for the gas-engine installation. In other words, according to his figures, if furnace gas were obtained for nothing, and if coal was $1.80 a ton, the result at the end of the year would come out about even.

In his figures he put in furnace gas free, so that if the engine could be brought to such a point of economy as to run without gas, his calculation would hold good provided it cost 5 per cent more to keep up the gas engines than the steam turbines; but he thought 15 per cent would be getting nearer to it.

Joseph Morgan called attention to the fact that the value of the surplus gas and the power generated from it depend entirely on how much can be sold. If there is no market for the power, the gas is worth nothing, while the value of a coal pile remains until used.

C. J. Bacon and H. J. Freyn. An analysis (Table 2) of the financial considerations involved in a comparison of a turbo-blower equipment with a gas blowing-engine equipment for blowing a blast-furnace plant consisting of four 500-ton furnaces, leads to results indicating that the total expense for fuel, operation and fixed charges is less for a turbo-blower installation than for a slow-speed gas blowing-engine installation in localities where the price of coal establishes a value lower than approximately $0.08 per 1,000,000 B.t.u. in the blast-furnace gas; and is less for turbo-blowers than for high-speed gas blowing engines where the price of fuel is lower than approximately $0.05 per 1,000,000 B.t.u. This conclusion is based on normal conditions prevailing in the average blast-furnace plant, but is influenced considerably by blast pressure, efficiencies, price of labor, water supply for condensers, value set on gas, cost of machinery and construction material, rate of interest, taxes, insurance, estimates of life of apparatus, method of computing depreciation, etc.

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[1] Consulting Engineer, Pittsburgh, Pa.

TABLE 2 TOTAL EXPENSE INCLUDING FUEL, OPERATION AND FIXED CHARGES

Cost of Fuel, Cents per 1,000,000 B.t.u.	Turbo-Blowers		Gas Blowing Engines			
			Slow-speed		High-speed	
	Yearly	Per 1,000,000 Cu. Ft.	Yearly	Per 1,000,000 Cu. Ft.	Yearly	Per 1,000,000 Cu. Ft.
15 lb. Blast Pressure						
4	276700	3.70	340400	4.49	292460	3.85
6	324600	4.34	360000	4.75	312060	4.11
8	372100	4.97	379500	5.00	331560	4.37
10	420100	5.61	399100	5.26	351160	4.63
12	468100	6.25	418700	5.52	370760	4.88
14	516100	6.90	438200	5.77	390260	5.14
20 lb. Blast Pressure						
4	300100	4.06	350100	4.61	302160	3.98
6	359100	4.80	374500	4.94	326560	4.30
8	419100	5.60	398900	5.26	350960	4.62
10	478100	6.39	423300	5.58	375360	4.94
12	537100	7.17	447700	5.90	399760	5.27
14	597100	7.98	472100	6.22	424160	5.59

For blowing four 500-ton furnaces there would be required eight gas blowing engines, including two spare engines, each with sufficient capacity for supplying two-thirds of the air required per furnace at a normal pressure between 15 and 20 lb. gage and occasionally as high as 25 lb. The usual displacement for a 500-ton furnace is 40,000 cu. ft. per min., although the amount of air actually discharged is somewhat below this figure and is considered as 89 per cent or 35,600 cu. ft. on the basis of actual measurements. Slow-speed engines are supposed to have a displacement of approximately 500 to 600 cu. ft., and high-speed engines approximately 360 cu. ft. In the case of the turbo-blower installation, six units would be required, including two spare units, each of 35,600 cu. ft. per min. actual discharge capacity at the same pressures. A convenient basis for comparing the costs of operation of different installations is per 1,000,000 cu. ft., in which connection each of the plants under consideration has a total yearly capacity of 74,845 million cu. ft. at 35,600 cu. ft. per min. per furnace.

In preparing the above figures it is assumed that the entire plant of four furnaces would operate continuously at the rated capacity of 500 tons per day. In case of reduced output or of partial shutdown due to dull business, relining furnaces, etc., the reduction in the item of fuel expense would be about twice as great with turbo-blowers as with the gas engines, while the item of fixed charges would continue at the same rate, resulting in a greater net decrease in the total expense for the turbo-blowers than for the gas engines.

Moreover, as certain approximately equal percentage allowances are made in the various efficiencies leading to a comparison of the heat consumption to take account of the actual operating conditions over long periods, any change in the fuel cost due to over-estimating such allowances would also result in a greater net decrease of total expense of the turbo-blowers than the gas engines.

Fuel Expense. Blast-furnace gas, after being subjected to preliminary cleaning, is burned under boilers for furnishing steam power for the turbo-blowers which are direct connected to high-pressure steam turbines. For the gas blowing engines the gas is given both primary and secondary cleaning. In each case the same value is set on the B.t.u. contained in the raw or uncleaned gas according to the local price of coal. This is an equitable basis since a furnace plant of this size would be in close proximity to steel mills in which the power produced from surplus blast-furnace gas is entirely used, thereby displacing coal which otherwise would be burned. The gas is therefore not a waste product.

Since the B.t.u. per lb. of coal, as well as the price, vary greatly in different localities, a unit of cost of fuel per 1,000,000 B.t.u. is used to facilitate comparisons. In the Pittsburgh district the cost is between \$0.035 and \$0.05 per 1,000,000 B.t.u.; in Ohio, \$0.05 to \$0.065; in Illinois and Indiana about \$0.08.

The heat consumption for blowing the furnace plant under consideration involves a comparison of the various efficiencies affecting the conversion of the heat in the gas into power as represented by the actual delivery of compressed air. In assigning values, the results of actual performance under operating conditions are used in all cases where applicable data are available (Table 3).

TABLE 3 DATA AND METHOD USED IN OBTAINING THE FUEL EXPENSE

Type of Equipment	Turbo-Blower		Gas Blowing Engine	
Blast pressure, lb. per sq. in.	15	20	15	20
M.e.p. of adiabatic compression, lb. per sq. in.	11.4	14.2	11.4	14.2
M.e.p. in air tubs of blowing engine, lb. per sq. in.	......	......	12.1	15.1
Efficiency of compression, per cent	......	......	94	94
Displacement of tubs per furnace, cu. ft. per min	......	......	40000	40000
Volumetric efficiency, per cent	......	......	89	89
Air delivered to blast mains, cu. ft. per min	35600	35600	35600	35600
Theoretical air, h.p. per furnace	1775	2210	1775	2210
Air h.p. of blowing engine per furnace	......	......	2115	2670
Mechanical efficiency of tub, per cent	......	......	92	92
Shaft efficiency, per cent	70	70	77	77
B.h.p. per furnace	2536	3156	2304	2869
Steam consumption, lb. per h.p-hr.	12.5	12.5	......	......
Thermal efficiency at shaft, per cent	9.46	9.46	21	21
Thermal efficiency at theoretical air h.p., per cent	6.62	6.62	16.2	16.2
Heat consumed per furnace, 1,000,000 B.t.u. per hr	68.2	84.8	27.9	34.8
Yearly cost of fuel per 1,000,000 B.t.u for four furnaces				
At $0.04	$ 95600	$119000	$ 39100	$ 48800
At 0.06	143500	178000	58700	73200
At 0.08	191000	238000	78200	97600
At 0.10	293000	297000	97800	122000
At 0.12	287000	356000	117400	146400
At 0.14	335000	416000	136900	170800
Cost of fuel per 1,000,000 B.t.u. per 1,000,000 cu. ft. air				
At $0.04	$1.28	$1.59	$0.52	$0.65
At 0.06	1.92	2.38	0.78	0.95
At 0.08	2.55	3.18	1.05	1.30
At 0.10	3.91	3.97	1.31	1.63
At 0.12	3.83	4.75	1.57	1.96
At 0.14	4.47	5.56	1.83	2.28

Notes on the Turbo-Blower. The shaft efficiency, or the relation of the power in the discharged air to the shaft power for the particular turbo-blower under discussion is shown to be 70 per cent. Recent developments in larger sizes, it is claimed however, have resulted in as high as 72.5 per cent, but as there is no assurance as yet that the efficiency can be continuously maintained at that point under actual operating conditions, 70 per cent is taken as a fair figure for this comparison.

The steam consumption is taken at 12.5 lb. per b.h.p-hr. At 135 lb. gage pressure, 125 deg. superheat and 28.5 in. vacuum and an efficiency referred to the Rankine cycle of 60 per cent, which may be expected from a turbine of this size, the steam consumption would be 11.9 lb., which is increased to 12.5 due to the effect of variation of operating conditions.

A boiler efficiency of 62.5 per cent is the actual performance shown by numerous tests of gas-fired boilers with superheaters operating under the normal conditions prevailing at a blast-furnace plant. It is estimated that 8 per cent of the total steam generated goes to auxiliaries of boilers and turbo-blowers and to miscellaneous losses. The boilers for the turbo-blowers are considered as operating at 140 lb. gage pressure, 150 deg. superheat and 70 deg. hot-well temperature. Under these conditions, the thermal efficiency of the turbo-blower installation complete would be 9.46 per cent at b.h.p., or 6.62 per cent at h.p. of adiabatic compression.

Notes on the Gas Blowing Engine. The shaft efficiency, or the relation of the power represented by the actual volume of compressed air to the power required at the shaft, consists of compression, volumetric and mechanical efficiencies.

The compression efficiency is the ratio of the work required adiabatically to the work actually done in the blowing tub. The losses consist principally of those due to inertia and mechanical friction of the discharge valves, to the friction of air through the passages and to late opening of suction valves when such occurs. These sources of loss, taken together, amount to an increase in work of 15 to 18 per cent over theoretical adiabatic compression for certain types of pot valves which require considerable excess pressure for opening. The thin plate automatic valves on Slick tubs show very small losses; in fact, tests made on Snow engines show less actual work than theoretical adiabatic compression. Radiation and water-cooled heads have a varying effect on the power requirement. The results of tests on a number of different kinds of blowing tubs show an average loss of about 6 per cent or an efficiency of compression of 94 per cent for the usual blast pressure of 15 to 20 lb., but varying from 82 to 94.6 per cent within the range of 5 to 30 lb. pressure.

The volumetric efficiency is the ratio of the measured volume of air actually delivered (reduced to atmospheric pressure) to the volume of piston displacement. The losses consist of: (*a*) those shown on indicator cards due to the effect of clearance and friction of air through suction valves, which usually range between 0 and 5 per cent; (*b*) leakage of air past the suction valves, discharge valves and piston; (*c*) the effect of preheating the incoming air during the suction stroke by contact with the surface left hot by the preceding discharge stroke. Tests made on seven blowing engines, part with Southwark tubs and part with Allis-Chalmers tubs having Reynolds valves, show volumetric efficiencies varying from 79.2 to 89.4 per cent, with blast pressure ranging from 10 to 20 lb. approximately. As some of the engines tested had been in service a number of years and were consequently not of recent design nor in first-class condition, it is not reasonable to consider the results obtained therefrom in establishing a rational figure for tubs of modern design and in fair condition. Volumetric efficiencies of 85 to 98.4 per cent were obtained from Allis-Chalmers tubs with Reynolds pot discharge valves, and as this engine had been in service between two and three years, it may be considered in fair condition. Consequently, in this discussion 89 per cent is taken applying at 15 lb. blast pressure, but varying from 91 to 86 per cent at 5 and 30 lb. blast pressure respectively.

The mechanical efficiency of the air tub, or the ratio of the work shown on the air card to the work required at the shaft, ranges from 86.8 per cent at 5 lb. pressure to 95.8 per cent at 30 lb. pressure. Tests on the Snow engines with Slick tubs show 500 h.p. friction loss between the gas and air cylinders, when blowing 35,400 cu. ft. displacement, or 60 r.p.m. at 15 to 20 lb. blast pressure. The actual horsepower developed in the gas cylinders was 2400, while 1900 was shown in the air cylinders, or 500 h.p. loss. As the speed during the tests was greater than necessary for blowing two-thirds of the requirement of a blast furnace, the friction is taken at 420 h.p., the actual loss shown at the required speed. Taking 420 h.p. as the average total friction loss between gas and air cylinders, the corresponding mechanical efficiency is 79 per cent at 1980 i.h.p. which the Snow tests showed necessary in the gas cylinders for 45 r.p.m., or 26,670 cu.ft. displacement at 20 lb. blast. Records of tests on electric engines of similar size and load show about 84 per cent efficiency between gas cylinders and shaft. The difference between 79 per cent and 84 per cent is 100 h.p. chargeable to air tub friction. The remaining 320 h.p. is the friction loss between gas cylinders and shaft. Therefore the shaft horsepower is 1980 − 320, or 1660. The friction loss of the tubs is $\frac{100}{1660}$, or 6 per cent, and the mechanical efficiency is 94 per cent. This applies to Slick tubs having a minimum of valve gear. For the average of various types of tubs the mechanical efficiency is taken at 92 per cent. These three efficiencies of the air tub taken together show a net shaft efficiency of about 77 per cent within the range of 15 to 20 lb. blast pressure.

The thermal efficiency at the shaft is about 21 per cent for normal operation at a blast pressure between 15 and 20 lb., which is based on the results obtained from tests on Snow engines. Two series of tests were made, one at constant pressure of 20 lb. with variable speed, and the other at constant speed of 60 r.p.m. with variable pressure. The former showed a thermal efficiency of 30 per cent referred to the i.h.p. of the gas cylinders at 40 to 65 r.p.m. and the latter showed 29 per cent on the same basis at 10 to 20 lb. blast pressure. These efficiencies referred to the gas cylinder power are equivalent to 24 or 25 per cent thermal efficiency referred to shaft power. These tests were made at higher loads than necessary for blowing two-thirds of the requirement of a blast furnace, at which load 23 and 24 per cent were obtained. Since the results were secured during comparatively short test periods of four hours each and since there is no assurance that they would be duplicated in long periods, 21 per cent thermal efficiency is considered a reasonable figure for the purpose of this discussion.

The net thermal efficiency referred to the theoretical air horsepower is the product of the shaft efficiency and the thermal efficiency at the shaft. This amounts to 16.2 per cent at 15 to 20 lb. blast pressure and varies from 9.5 per cent at 5 lb. pressure to 17.8 per cent at 30 lb. pressure.

Operation Expense. As in the case of cost of installation it has been necessary to estimate the costs of the items making up the total cost of operating the turbo-blower equipment. The basis for estimating the gas-cleaning and boiler-plant expense is the actual cost of similar operation under steel-mill conditions and the expenses applying to the turbo-blowers are based on detailed analysis of the various operating costs of a number of high-grade turbo-electric plants of the same size approximately, which seem to be proper sources of data on account of the similarity of equipments. In the case of gas blowing engines the operation expense is the direct result of comparing the actual costs for several gas blowing plants.

COST OF OPERATION (WITHOUT FUEL) OF TURBO-BLOWER INSTALLATION FOR FOUR 500-TON BLAST FURNACES

	Per Year	Per 1,000,000 Cu. Ft. Delivered (74,845 million)
Gas cleaning	$ 8,500	$0.113
Boiler plant expenses	24,000	0.321
Engineers, wipers, etc.	14,600	0.199
Labor and material in repairs and maintenance	10,000	0.134
Lubricants	750	0.010
Tools and miscellaneous supplies	750	0.010
Water	2,500	0.033
Total	**$61,100**	**$0.820**

COST OF OPERATION (WITHOUT FUEL) OF GAS BLOWING ENGINE INSTALLATION FOR FOUR 500-TON BLAST FURNACES

	Per Year	Per 1,000,000 Cu. Ft. Delivered (74,845 million)
Cost of purification..	$17,600	$0.235
Engineers and wipers	21,100	0.282
Labor and material in repairs and maintenance..	20,000	0.268
Lubricants	8,200	0.110
Tools and miscellaneous supplies	850	0.010
Water	4,400	0.059
Electric power	350	0.005
Total	$72,500	$0.970

Fixed Charges. Since there are no turbo-blower installations of this particular size and equipment, the cost of installation has been estimated with due consideration of available data on actual costs of material and construction of similar apparatus. In the case of the slow-speed gas blowing engines, the cost is an estimate on a model installation, combining the best features of a number of actual plants and making use of data on the actual expenditures for plants of capacities almost identical with the turbo-blower installation. Although there are at hand no data on the costs of exclusively high-speed, gas blowing-engine installations, use has been made of the afore-mentioned data on slow-speed equipments modified to take account of reduced space and present prices of the high-speed equipment.

COST OF INSTALLATION AND FIXED CHARGES ON A TURBO-BLOWER EQUIPMENT COMPLETE FOR FOUR 500-TON BLAST FURNACES

	Cost		Estimated Life, Years	Depreciation at 6 Per Cent Interest	Sinking Fund Per Year	
Gas-cleaning plant		$27,000	15	4.2		$1,130
Boiler house						
Excavating and filling	$1,800		..	...	...	
Foundations	2,520		20	2.8	70	
Building	30,600		20	2.8	860	
Floors, etc..	1,080		20	2.8	30	
Total		36,000		2.8		960

Cost of Installation and Fixed Charges on a Turbo-Blower Equipment Complete for Four 500-Ton Blast Furnaces—*Continued*

	Cost		Estimated Life, Years	Depreciation at 6 Per Cent Interest	Sinking Fund Per Year	
Boilers						
Excavating and filling.....	1,080		..	...	..	
Foundations	5,400		18	3.3	180	
Boilers complete...........	100,800		18	3.3	3,320	
Steam pipes...............	28,800		18	3.3	950	
Feedwater system..........	18,000		15	4.2	760	
Blow-off pipes, etc.	4,320		15	4.2	180	
Gas flues, burners, etc.....	25,200		10	7.2	1,810	
Superheaters.............	32,400		10	7.2	2,330	
Total....................		216,000		4.4		9,530
Building for turbo-blower						
Excavating and filling.....	2,500		..	...	...	
Foundations...............	4,000		20	2.8	110	
Building..................	26,000		20	2.8	730	
Floors, etc................	8,000		15	4.2	340	
Crane.....................	7,500		15	4.2	320	
Total....................		48,000		3.1		1,500
Turbo-blowers						
Excavating and filling.....	5,000		..	...	...	
Foundations...............	10,000		15	4.2	420	
Turbo-blower erected......	320,000		10	7.2	23,000	
Condenser.................	120,000		10	7.2	8,640	
Piping and sewers.........	45,000		10	7.2	3,240	
Blast pipes................	48,000		18	3.3	1,580	
Total....................		548,000		6.7		36,880
Total investment........		875,000				

Fixed charges	Per Cent	Per Year
Depreciation................	5.7	50,000
Interest on investment......	6.0	52,500
Taxes.......................	1.5	13,120
Insurance..................	0.5	4,380
Total.....................	13.7	120,000
Total per 1,000,000 cu. ft. air....................		1.60

Cost of Installation and Fixed Charges for a Slow-Speed Gas Blowing Engine Equipment Complete for Four 500-Ton Blast Furnaces

	Cost		Estimated Life, Years	Depreciation at 6 Per Cent Interest	Sinking Fund Per Year	
Gas-cleaning plant						
Excavating and filling....	$2,400		..	...	...	
Foundations.............	9,000		10	7.2	650	
Building.................	7,000		15	4.2	300	
Gas washers (static).....	37,000		15	4.2	1,550	
Gas holder...............	8,200		15	4.2	340	
Machinery (rotary washer)	23,200		10	7.2	1,670	
Piping..................	29,200		15	4.2	1,230	
Total.................		116,000		4.9		5,740
Building for engines						
Excavating and filling...	7,000		...	...	...	
Foundations.............	14,000		20	2.8	390	
Building................	122,000		20	2.8	3,420	
Floors..................	34,000		15	4.2	1,430	
Crane...................	12,000		15	4.2	500	
Total.................		189,000		3.0		5,740
Gas blowing engines						
Excavating and filling....	14,000		..	...	....	
Foundations.............	60,000		15	4.2	2,520	
Engines.................	1,096,000		10	7.2	78,910	
Piping..................	60,000		10	7.2	4,320	
Blast pipes.............	75,000		18	3.3	2,770	
Total.................		1,305,000		6.8		88,520
Total investment......		1,610,000				

Fixed charges	Per Cent	Per Year
Depreciation...............	6.2	100,000
Interest...................	6.0	96,600
Taxes......................	1.5	24,150
Insurance..................	0.5	8,050
Total....................	14.2	228,800
Total per 1,000,000 cu. ft. air....................		3.06

Cost of Installation and Fixed Charges for a High-Speed Gas Blowing Engine Equipment Complete for Four 500-Ton Blast Furnaces

	Cost		Estimate Life, Years	Depreciation at 6 per Cent Interest	Sinking Fund Per Year	
Gas-cleaning plant						
Excavating and filling.....	$2,400		..	...	...	
Foundations...............	9,000		10	7.2	650	
Building..................	7,000		15	4.2	300	
Gas washers (static).......	37,000		15	4.2	1,550	
Gas holder................	8,200		15	4.2	340	
Machinery (rotary washers)	23,200		10	7.2	1,670	
Piping....................	29,200		15	4.2	1,230	
Total..................		116,000		4.9		5,740
Building for engines						
Excavating and filling.....	5,000		..	...	...	
Foundations...............	10,000		20	2.8	280	
Building..................	93,500		20	2.8	2,620	
Floors....................	26,000		15	4.2	1,090	
Crane..	9,500		15	4.2	400	
Total......		144,000		3.1		4,390
Gas blowing engines						
Excavating and filling.....	10,000		..	...	....	
Foundations...............	40,000		15	4.2	1,680	
Engines...................	842,000		10	7.2	60,620	
Piping....................	55,000		10	7.2	3,960	
Blast pipes...	70,000		18	3.3	2,310	
Total......		1,017,000				68,570
Total investment...		1,277,000				
				Per Cent		Per Year
Fixed charges						
Depreciation...............				6.2		78,700
Interest..........				6.0		76,620
Taxes......................				1.5		19,155
Insurance				0.5		6,385
Total......				14.2		180,860
Total per 1,000,000 cu. ft. air.						2.41

Notes on Turbo-Blower Installation. The gas-cleaning plant is composed of static wet cleaners of the tower type with a capacity of 3,300,000 cu. ft. per hr. cleaned to 0.25 grain per cu. ft.

The boiler plant consists of 7200 h.p. of water tube gas-fired boilers with provision for coal firing, superheaters, feedwater system, steam and water piping contained in an all-steel building of the class common in steel plants. The normal requirement of the turbo-blowers including auxiliaries and losses is 6000 b.h.p., the remaining 1200 h.p. being for spare use and cleaning.

The turbo-blower plant includes six turbo-blower units driven by direct-connected high-pressure steam turbines, each having a rated capacity of 35,600 cu. ft. per min. at 15 to 20 lb. blast pressure, there being two units to spare. Each blower has a surface condenser for 40,000 lb. of steam per hour and 28.5 in. vacuum with 70 deg. water. Each condenser requires 7200 gal. of circulating water, pumped by an 18-in. centrifugal pump for each unit. The circulating and hot-well pumps are driven by steam turbines and the air pump by a reciprocating engine. All auxiliaries are located in the basement. The water supply to the pumps is through a 7-ft. conduit, assumed 400 ft. long, and the sewer is of similar size and length. The blast piping includes receivers, valves, cross-connections and all piping to the mains outside the building. The building is 50 ft. by 175 ft. of brick, painted inside, with concrete floor.

Notes on Gas Blowing Engine Installation. The gas-cleaning plant consists of a preliminary and a secondary part, the former comprising three wet scrubbers (tower washers) and the latter three Theisen gas washers operated by electric motors. The mechanical equipment (rotary washers) is installed in a steel building with brick walls, painted inside and provided with all auxiliaries such as pumps, switchboard, wiring, gages, safety appliances, etc. A small gas holder acting as gas-pressure regulator is included, as well as a settling tank to purify the waste water from the gas-cleaning plant and all the piping connecting the various parts of it also provided. The total capacity would be about 25,000 cu. ft. of gas per minute.

The blowing-engine house is a steel frame building with brick walls, painted inside, large windows, ventilation, a skylight, reinforced concrete floors, a spacious basement 10 ft. high, 30-ton electric traveling crane with main and auxiliary hoist, safety and sanitary appliances, electric lighting, office, etc. The width of the building for slow-speed blowing engines is about 105 ft. between the center line of columns and it is about 90 ft. for high-speed gas blowing engines.

The gas blowing-engine equipment consists in the case of slow-speed, gas blowing engines of eight double-acting, twin-tandem, gas engines about 42 in. by 60 in. stroke, operating blowing tubs of about 72 in. in diameter at a normal speed of 50 to 60 r.p.m. The alternative case of high-speed engine equipment comprises eight double-acting, twin-tandem, gas blowing engines; about 38 in. in diameter of gas cylinders; 64 in. in diameter of blowing tubs, 50 in. stroke, operating normally at about 85 to 90 r.p.m.

Depreciation is understood as the amount of money set aside yearly, which compounded at an accepted rate of interest would equal the original investment at such a time as replacement is necessitated through obsolescence, age or inadequacy.

From these figures it will be seen that while a turbo-blower installation under certain conditions is more economical from a commercial standpoint than an installation of slow-speed gas blowing engines, modern high-speed gas blowing engines, as advocated by Mr. Trinks[1] and as used in German blast furnaces and steel plants, offer marked advantages over the turbo-blower as a financial investment.

The present tendency towards high-speed machinery is sure to extend its influence to the gas engine and particularly the gas blowing engine. The only difficulty which so far has stood in the way in this country of the development of high-speed gas blowing engines is the lack of a blowing tub which would operate successfully on high speeds. This side of the proposition has been very ably and fully dealt with in Mr. Trinks' paper[1].

A recent trip through Europe has revealed the fact that in spite of the development of the turbo-blower by several manufacturing concerns in Germany, the gas blowing engine is more than holding its own, due to the high price of coal, since certain turbo-blower installations did not give as satisfactory results as had been claimed for this type of blowing engine.

Looking at the proposition merely from a short-range commercial standpoint, it must be conceded that for isolated blast-furnace plants where no use can be made of the excess gas produced by the blast furnaces, the turbo-blower is unquestionably very desirable, in fact, unsurpassed as an ideal apparatus for blowing smaller furnaces, and it is likely to prevent very successfully the introduction of gas blowing engines in such cases, except when blast-furnace proprietors in a district reach such an agreement as exists in several instances in

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[1] Reciprocating Blast-Furnace Blowing Engines, W. Trinks, The Journal, Am. Soc. M. E., July 1911, p. 751.

Germany, for the purpose of producing cheap electric power for sale to communities and industrial establishments of all kinds located in the neighborhood of these isolated plants.

Thus, even in isolated blast-furnace plants very careful investigations should be made before the gas engine is discarded as a possible competitor for steam equipment, since a lucrative field for disposal of surplus electric power may be thrown open by the organization of such syndicates of otherwise competing blast-furnace and steel works. They would have the additional advantage that each constituent company could obtain power from the common system at low cost in case their own power production is curtailed by accidents to their machinery or by reduced output of their furnaces.

In spite of all computations endeavoring to prove that the steam turbine or turbine-driven turbo-blower are commercially superior on account of the low cost of installation and operation, it is impossible to get around the fact that the surplus gas of blast furnaces when converted into power in internal-combustion engines, yields over twice the amount of energy possible when the conversion takes place in the roundabout way of steam boiler and reciprocating engine or steam turbine. To emphasize this statement it needs only to be pointed out that of the total gas production of four 500-ton blast furnaces of about 13,000,000 cu. ft. per hr., there remains available for purposes outside the blast-furnace requirements themselves, 3,750,000 cu. ft. per hr. in the case of the turbo-blower installation, while this surplus amounts to 5,670,000 cu. ft. per hr. when gas blowing engines are used. In the former case an electric station of about 10,000 kw. capacity, equipped with steam turbines could be operated without burning additional coal under boilers, whereas in the latter case a gas-engine central station of about 30,000 kw. capacity could be installed and operated.

In view of the natural tendency towards reducing the cost of installation and operation of power plants and of the constant increase in the price of coal, it is very clear that the internal-combustion engine is bound to gain in value as a prime mover in the future. The smoke nuisance, the difficulties of coal shortage, car famine, etc., in the case of steam-power installations are mentioned only incidentally in their influence upon the probable development of gas power.

Recently means have been found to increase still further the efficiency of gas-power plants by recovering the waste heat formerly lost in cooling water and exhaust. Experiences in a large Belgian blast-furnace and steel plant have proved that about 13 per cent more power can be obtained from the same input of heat units by harnessing in the form of low-pressure steam a large portion of the waste heat of gas engines.

In power plants of the future, the installation of waste heat recovery appliances will permit of obtaining continuous high thermal efficiency of the gas engines by maintaining uniform high load on these engines, while peak loads will be carried by low-pressure, steam turbo-generators.

The suggestion offered by Mr. Johnson in regard to a combination of low-pressure steam turbo-blowers and reciprocating steam-blowing engines, can be considerably improved and elaborated upon, since it would seem much more economical to install in a new blast-furnace plant several large turbo-blowers, operated by low-pressure steam turbines, running on steam generated by the waste heat recovered from cooling water and exhaust of gas-electric and gas blowing-engines. These turbo-blowers would deliver the total amount of air necessary for all furnaces at low pressure into an air-tight tunnel or header, from which a number of gas blowing engines would be supplied. The latter would compress the blast in a second stage, as it were, to regular blast pressure.

With such a combination the fuel cost for obtaining low-pressure blast would be practically nothing and the cost of operation and fixed charges moderate, on account of the rotary type and reduced cost of installation of the first-stage machinery. Moreover, the first cost and operating expenses as well as fuel cost for the gas blowing engines themselves would be reduced, since a smaller number of smaller gas blowing engines would suffice. The volumetric efficiency of the blowing tubs would be practically 100 per cent, since the air delivered by the turbo-blowers could easily be cooled by means of pipe coils arranged in the air-tight tunnel, through which the engine cooling water would circulate before entering the gas-engine water jackets.

The safety of blast-furnace operation would suffer in no way, since in case of shutdowns of the turbo-blowers, the gas blowing engines would insure delivery of a reduced quantity of air; while in the event of trouble with the gas engines, large quantities of low-pressure air would be available to keep the gas out of the cold blast pipes.

Since conservative estimates show that at least 12 per cent of the power produced in gas engines is available for low-pressure steam turbines in the waste heat, 25 per cent and more of the power necessary for blowing the furnaces could be secured by the utilization of the waste heat from gas blowing engine and gas-electric engine installations.

The Author. The question of efficiency and accuracy of control of the rate of flow of air into the furnace, which is one of the vital questions to be considered in connection with turbo-compressors, consists in reality of two parts, (*a*) a knowledge of the exact rate of flow at any particular time, and (*b*) the accuracy with which this rate of flow can be changed. In both cases the turbo-compressor stands alone, and by virtue of the great accuracy with which the rate of flow can be determined, and controlled and varied through as slight or as great ranges as may be desired, will give unprecedented control over the variations of the furnace to the furnace man, and enable him to produce more uniform quality of iron under greater quantity from any given furnace.

The variation per stroke in volume discharged from any given reciprocating compressor when blowing at pressures of 10 or 20 lb. (both of which are common in practice), due to the variations in the quantity of air required to fill the clearance space at these different pressures, is far greater than the variations due to the inaccuracy of the calibration of the constant volume governor scale beam on the centrifugal compressors. In addition the reciprocating blowing engine suffers from variations due to leakages, pulsations in the blast main, and other causes which, when summed up, render uncertain the exact quantity of air flowing into the furnace. Uncertainties do not exist when the centrifugal compressor is used, for the blast-furnace operator is furnished with a means of measuring the air accurately and controlling it with any necessary degree of precision.

The method proposed by Mr. Dreyfus of blowing air to a constant pressure in a turbine-driven compressor and taking constant pressure into a reciprocating blowing engine is not one made necessary by the considerations set forth. The turbo-compressor can be designed with a reasonable number of stages to give pressures required in the normal operation of the blast furnace, and by a very moderate increase in speed it can be made to give, with good efficiency, the maximum pressures required in such service. Therefore it is not necessary to use this type of blowing engine as a booster. Simplification and accuracy of operation are obtained in the highest degree consistent with maximum economy by taking the air from the turbo-compressor directly into the furnace.

The method of operation where the turbo-compressor is used as a booster does not realize the full benefits of the accurate control and uniform flow of air afforded by the turbo-compressor, and it is therefore objectionable. It is, however, extremely economical to use steam from reciprocating blowing engines in a mixed pressure turbine driving a turbo-compressor, and several such installations are now in contemplation. In such cases, the best arrangement is for the reciprocating blowing engines to blow directly into one furnace, and the turbo-compressors into another, allowing each apparatus to be governed in the ordinary manner by its own governing mechanism.

The use of dry blast in a turbo-compressor results in increased efficiency, since the air is delivered to the turbo-compressor at a greater density than where it is taken from the atmosphere direct, and this greater density results in the production of the pressure at a lower speed and less consumption of steam.

The description of the centrifugal air compressor developed by the Westinghouse Machine Company and the high efficiencies claimed for this machine are extremely interesting. These latter would be gratifying if realized in practice, but tests of the Great Falls apparatus which have come under the knowledge of the writer indicate that the measurements of efficiency are made on an erroneous basis, and that such machines not provided with discharge vanes, but with rather imperfect types of impellers, are not able to give the efficiency realized by the apparatus which form the subject of the author's paper.

Mr. de Laval called attention to the fact that it is not necessary to use six stages in series for pressures as low as 10 to 20 lb. This is undoubtedly true where higher speed turbines are available for driving such apparatus. At the time the Empire machine was designed such was not the case. Machines for these pressures are now provided with only three stages and attain a higher efficiency because of the higher speed and the smaller losses resulting. Under these circumstances, it is not desirable to reduce the diameter of the second or third impeller as advocated by Mr. de Laval, but only in cases where the pressures to be realized are considerably higher.

The great differences between the Rateau multi-stage compressors and those of the type described by the author reside in the method of balancing end thrust, by Rateau in separate impellers and in the other type by double inlet impellers, and in the governing mechanism.

The arrangement of impellers used by Rateau results in "pumping" of air back and forth between one and the other at light loads. This pumping effect does not exist in the machine described.

The radical difference in the governing mechanism lies in the General Electric governing mechanism being placed on the inlet, and, therefore, subject to far less variations in density, pressure and temperature of air than where the governor is on the discharge.

Professor Trinks mentioned that many of the turbo-blowers abroad were not in operation. The author believes this to be due to the fact that the method of governing such machines is not sufficiently accurate to cause good results, whereas the accuracy of the apparatus described in this paper leaves nothing to be desired.

Mr. de Laval referred to an automatic outlet valve used to prevent detrimental pulsation of air at partial capacities. The same remarks that have been made in connection with the air governor apply to this apparatus. After extensive experiments the author believes it is much better to control the air pulsations by apparatus on the inlet than on the discharge.

It is gratifying to see that Messrs. Freyn and Bacon apparently agree that for installations involving the blowing of less than four furnaces, the turbo-blower is superior to the gas engine, since they do not attempt to study installations involving a smaller number of units. As regards their figures for plants involving blowing four furnaces or more, there are a number of serious objections to be made. In addition, the author feels that if Messrs. Freyn and Bacon had given full credit to the increased value of the output due to the more accurate governing of the turbo-compressor, and the consequently increased quality of the product and its increased amount due to the more uniform operation of the furnace resulting from the employment of the turbo-compressor with this method of governing, their conclusions would have been modified even in the case of the plants they discuss. It is difficult perhaps for furnace men to realize the value of this feature or to give it proper credit.

Referring to the figures for the installation and operating expenses of various plants, it will be noted that the assumption is made that each gas engine shall have a capacity to blow two-thirds of a furnace. Such a method of operation of furnace blowing units is extremely undesirable, since it leads to the imposition of tremendous strains upon the blowing engine, requiring the outlay of a considerably larger investment cost than has been used by these authors in their tables, or resulting in a much larger cost of repair and maintenance than they have used. Nothing approaching the best results in the operation of a blast furnace can be obtained by such a method of operation. The author knows of two cases where in the use of such a method serious difficulties and abnormal expenses for repairs to blowing engines resulted.

The adequacy of the number of units specified by these authors is questioned in the case of gas engines to provide the necessary amount of spares that the operation of the group of four furnaces can be maintained at full capacity at all times when the condition of the furnace renders such operation possible. Information from all sources as to the continuity of operation of gas engines for blowing blast furnaces confirms the opinion that instead of eight units as specified by Messrs. Freyn and Bacon, ten units would be none too many. If such is the case, the figures for the cost of installation, interest charges, repairs, operating costs, etc., must be considerably raised against the gas blowing engine with turbo-compressors for this purpose. In this case also, if sufficient first cost was put into the blowing engines to secure necessary reliability and to render the above number of units sufficient, the investment cost would have to be largely increased.

Messrs. Freyn and Bacon have assumed that the entire plant of four furnaces would operate continuously at the rated capacity of 500 tons per day. The author believes that such an installation operating continuously for any considerable length of time at the rated capacity has never existed. Messrs. Freyn and Bacon state: "In case of reduced output, or of partial shutdown, due to dull business, relining furnaces, etc., the reduction in the item of fuel expense would be about twice as great with turbo-blowers as with the gas engines, while the item of fixed charges would continue at the same rate, resulting in a greater net decrease in the total expense for the turbo-blowers than for the gas engines." That is to say, if ordinary instead of theoretical operating conditions had been assumed, the case for the turbo-blowers would be substantially improved.

The vital element in the argument of Messrs. Freyn and Bacon for the maintenance of the gas engine is the question of its efficiency of operation. It is to be regretted that it is not stated how the efficiency of the gas engine or reciprocating blowing tubs was ascertained. It is extremely difficult, if not impossible, to measure correctly by any means in common use the discharge of air from a reciprocating blowing apparatus, owing to the variations in pressure met with in the blast mains. This is due to the fact that the air is discharged from the blowing tub during only a fraction of the stroke, causing a pressure wave to proceed through the blast main at every stroke. It may be that the blast main in this particular case was so long that these fluctuations in pressure were smoothed out and became negligible; but it would be very interesting to have this point cleared up. If the quantity of air discharged was measured by the indicator card it must be obvious that large errors are likely to exist, and this would seriously affect the computations of efficiency. For instance, if a leak exists in the discharge valves the indicator cards will show a considerable amount of work performed while the air delivery is not in proportion to the amount of work so shown. In comparing turbo-compressors with reciprocating blowing apparatus of any type whatever, this fact should be kept clearly in mind. The quantities discharged by the turbo-compressor are accurately measured within 2 or 3 per cent. The quantity of air discharged by a reciprocating machine is not capable of accurate measurements in the ordinary installation, and figures of volumetric displacement as compared with actual delivery are admittedly at variance by considerable and variable percentages.

Messrs. Freyn and Bacon, in discussing the efficiency of turbo-compressors, assume a figure of 62½ per cent for boiler and furnace efficiency, which is perhaps justifiable if the plant is to be operated in the usual blast-furnace manner. It is practicable by the installation of superheaters and fuel economizers to secure with proper supervision 70 per cent efficiency. Of course if this per cent were used in computations, the figures for the turbo-blower installation would be greatly improved.

In discussing the turbo-blower, Messrs. Freyn and Bacon assume an operating steam gage pressure of 135 lb. There is no reason why a modern plant involving the installation of the best apparatus developed for the purpose could not operate at a pressure of 175 lb., but certainly any figures for cost of operation of turbo-blowers ought to be based on a pressure no lower than 150 lb. Furthermore, Messrs. Freyn and Bacon increase the steam consumption from 11.9 lb., which they derive from a consideration of factors, including this low steam pressure, and the use of efficiency of 70 per cent, which is lower than the figure they themselves give for the turbo-compressor (72½ per cent), and which is correct, to 12.5 lb., or an increase of 5 per cent. Since they have decreased the efficiency as above by 8⅛ per cent, this makes a total decrease of efficiency of the turbo-blower, to allow for variable conditions, of 8½ per cent. All the curves and tests on turbo-compressors made by the author indicate that this figure is very much too high. The figure given by Messrs. Freyn and Bacon for the performance of turbo-blowers is therefore unnecessarily conservative.

Although the loss by variation of conditions of air pressure and volume is greater in the gas engine than it is in the steam turbine, no allowances for the effect of these variations have been made by Messrs. Freyn and Bacon in discussing the efficiency of the gas engine, while they have been made when discussing the turbo-compressors. If these allowances are eliminated and 70 per cent is used for furnace efficiency the thermal efficiency of the turbo-blower installation complete would be 11.6 per cent at brake horsepower, or 8.1 per cent at horsepower of adiabatic compression, instead of 9.46 and 6.62 given by these writers. These figures would modify considerably the comparison with the gas engine.

The thermal efficiency of 21 per cent at the shaft, which Messrs. Freyn and Bacon give for the gas blowing engine, should be reduced to at least 19 per cent, if the results of the variations met with in practice are taken into account. In all probability, under all the variable conditions of blast-furnace operation this efficiency would be considerably less than 19 per cent. This would also reduce the thermal efficiency at theoretical air horsepower, given by these writers as 16.2, to not more than 14.6.

In regard to the cost of operation and maintenance, it is of course very difficult to get any figures on the actual cost of operation of installations of either type of blowing apparatus, but from available information the author is inclined to question seriously the adequacy of the item of "labor and material in repairs and maintenance of the gas blowing engine at $20,000 per annum," as being in any way sufficient to cover the cost of this item for an installation of 8 or 10 gas blowing engines.

Referring to the statement of these authors, "In spite of all computations endeavoring to prove that the steam turbine or turbine-driven turbo-blower are commercially superior on account of the low cost of installation and operation, it is impossible to get around the fact that the surplus gas of blast furnaces when converted into power in internal-combustion engines yields over twice the amount of energy possible when the conversion takes place in the roundabout way of steam boiler and reciprocating engine, or steam turbine," it should be borne in mind that the output of gas from a blast furnace is variable and irregular in amount. The author believes that Messrs. Freyn and Bacon do not take sufficient account of the irregularity of operation of plants depending on this gas for their motive power, where such plants cannot be provided with additional sources of heat, for instance, by hand-fired boilers. It is true that a gas engine can use only gas, and if the gas supply is not sufficient, the gas engine must give out a reduced output, or shut down. In the case of a steam plant containing boilers, if the gas supply is insufficient, the capacity can be kept up by hand-firing of coal. In the case of a gas engine, unless an expensive plant of producers is installed, a deficiency in output will be experienced under such conditions. For these reasons, speculations as to the value of the additional gas set free by the use of a more economical blowing engine must be considered in the light of this irregularity, and additional apparatus consisting of steam engines or steam turbines, provided with the necessary boilers, etc., or a plant of gas producers must be installed to supplement the gas-engine plant if regularity of operation is to be expected and regularity of output ensured. Furthermore, it is difficult properly to govern a gas engine to ensure the necessary regularity and frequency of voltage, and it has been found necessary in some cases to install one or more steam turbines in connection with a gas-engine electric plant taking its gas supply from blast furnaces, in order to provide the necessary regulation. The cost of such installations ought to be added to the cost of investment in the gas-engine plant in order to bring the figures up to a fair basis of comparison.

It should also be borne in mind that the present direction of progress in the operation of blast furnaces is towards a reduction in the amount of the fuel burden. For many years blast-furnaces have been using about twice the theoretical quantity of fuel. It is not impossible that in the near future this figure will be greatly reduced, resulting (*a*), in a decrease in the quantity of gas, and (*b*), in a decrease in its quality. This deficiency will have to be made up by hand-fired boilers or coal-fired producers. Considering the comparison between steam and gas units under these conditions it should be borne in mind that the gas producer is an inefficient piece of apparatus and this, with the low combined efficiency of all the conversion processes involved, will militate against it in such a comparison.

Messrs. Freyn and Bacon devote considerable space to the discussion of a combination of a gas-blowing installation and gas-electric station to which are attached several large turbo-blowers operated by low-pressure steam turbines running on steam generated by the waste heat recovered from cooling water and exhaust. The undesirable features of the tandem operation of turbo-blowers and gas blowing engines which these writers advocate has already been dealt with. The author furthermore believes that they greatly overestimate the quantity of such available heat, which under the most favorable conditions would amount to not more than 10 per cent. Moreover, he cannot see how under such a combination of conditions such as the writers set forth, a volumetric efficiency of anything like 100 per cent could be secured. He is ready to admit, however, that the leakages would be somewhat reduced by reason of the lower range of pressures dealt with by the reciprocating compressor, but the main causes for the low volumetric efficiency would still remain present.

In conclusion, taking figures obtainable by the average purchaser, made up on the basis used by Messrs. Freyn and Bacon, and giving full credit to the turbo-blower for all improvements made in the operation of the furnace, both as regards quantity and quality of output for the average plant, the gas engine will be found to have a very limited field of application, and only in the very largest plants and under the most favorable conditions in regard to fuel cost will it be found desirable to install such apparatus.

FOREIGN REVIEW

THE AMERICAN SOCIETY OF MECHANICAL
ENGINEERS

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Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *a* comparative; *b* descriptive; *c* experimental; *d* historical; *e* mathematical; *f* practical; *g* general; *h* theoretical. Articles of exceptional merit are rated *A* by the reviewer.

Aeronautics

La turbine à air comme propulseur, C. Canovetti. *L'Aérophile*, December 15. 4 pp., 9 figs. *dh*. Airships can be better propelled by an *aerial turbine* than by a propeller with blades, an aerial turbine being practically a propeller enclosed in a casing, and having a large number of blades. The efficiency of such a turbine would be a function of the ratio n of the absolute velocity V of the efflux of the air and its velocity u of translation; the practical value for this ratio is between 0.5 and 0.6; the useful work increases with V, and decreases as n increases, becoming zero for $n = 1$, and passing through a maximum at $n = 0.5$. The author had a 3 h.p. model constructed in 1906 which does not appear to have given satisfactory results.

Indicateur automatique de dérive. *La France automobile et aérienne*, December 2. 1 p., 3 figs. *b*. Description of an *apparatus* designed by Poulalion and Armange for *automatically indicating the drifting of an airship*. The principle of the indicator consists in placing a flexible membrane vertically and parallel to the axis of the airship, in such a manner that the membrane will deflect under the influence of the component representing the force of the drift, and in proportion to its magnitude, and registering the deflection mechanically or electrically.

Air Machinery

Untersuchungsstelle für Pressluftmaschinen, K. Wortmann. *Glückauf*, December 9. 1½ pp., 4 figs. *b*. Description of an *Installation for testing compressed air machinery* at the mines of the Zeche Consolidation in Gelsenkirchen.

*Untersuchungen an Ventilatoren, A. Johnen. *Zeits. für Elektrotechnik und Maschinenbau*, November 30. 3 pp., 7 figs., 2 curves. Experimental data on *ventilators*.

Fuel

Nouvelle méthode d'essai des charbons de Mr. le Dr. H. Strache. *Journal des usines à gaz*, December 5. *b*. Description of a new *method of testing coal* used at the Technical School in Vienna. Dr. Strache's apparatus consists of a tube of glass having a very high melting point, in which 1 to 2 decigrams (0.22 to 0.44 lb.) of coal are gasified. The tar produced is absorbed by an asbestos plug, and the gas is conducted to a calorimeter.

A certain amount of it is mixed with air, in any proportion, and exploded by an electric spark in an explosion pipette. The heating value is given by direct reading; the weight of the little tube, before and after gasification, gives the weight of the gas escaped, and coke produced; by weighing in a similar manner the asbestos plug the weight of the tar is obtained. What remains in the little tube (*i.e.*, the coke) is then burned in a current of oxygen, and the contents of carbon, hydrogen, and ash are determined. Finally it is easy to determine the percentage of CO_2 in the products of combustion which permits of determining the percentage of carbon in the gas produced. The method is rapid, and is said to give good results.

DAS SAUERSTOFF-VERHÄLTNIS UND DIE WÄRMEKRÄFTE BEI VERBRENNUNGSVORGÄNGEN. *Zeits. für Sauerstoff-und Stickstoff Industrie*, November. 2½ pp., 1 Fig. *dh.* One of a series of articles on the development of, and principles underlying, the better and more economical *methods of using fuels.* A longer abstract of the whole series of articles will be given later.

MACHINE À EXTRAIRE LA TOURBE, SYSTÈME STRENGE. *Le Génie civil*, December 2. 1 p., 1 Fig. *b.* Description of the Strenge (German) machine for cutting, mixing, pressing, and spreading *peat.*

MASCHINELLE FEUERUNG FÜR BRAUNKOHLENBRIKETTS. *Elektrotechnischer Anzeiger*, December 7. 2 pp., 6 figs. *b.* Discussion of *mechanical stoking for lignite briquettes*, and description of the Pluto stoker, and a so-called self-stoker.

ZENTRALANLAGEN ZUR BESEITIGUNG DES RAUCHES, O. B. *Prometheus*, December 2. 1 p. *g.* Discussion of the plan proposed by Fichtl and Lemberg for the abatement of smoke in cities. The plan consists in conveying all the smoke from residence chimneys and factory stacks by underground passages to one central purifying plant where useful by-products would be separated, and the whole so purified that only oxygen and carbon dioxide would be left free to escape into the air. The author believes in the technical feasibility of the project, but points out the great difficulty of making it pay, at least apart from indirect benefits that might accrue to the community in the form of better health and cleaner air.

Furnaces

DIE ANWENDUNG DER GESETZE DER HYDRAULIK AUF DIE BERECHNUNG DER FLAMMÖFEN. *Stahl und Eisen*, December 7 and 22. 15 pp., 7 figs. *hA.* Exposition of Prof. Grum-Grzimailo's theory of the applicability of the laws of hydraulics to the calculation of *furnaces*, in particular reverberatory.

NEUE HEIZ-UND SCHWEISSBRENNER FÜR GASFÖRMIGE UND FLÜSSIGE BRENNSTOFFE. *Zeits. für Beleuchtungswesen*, November 30 and December 10. 5 pp., 10 figs. *b.* Description of the latest types of *burners for gaseous and fluid fuels*, containing drawings and short extracts from German patents.

Gas Plant Engineering

DIE GEWINNUNG DER NEBENERZEUGNISSE BEIM GASERZEUGERBETRIEB, A.

Gwigger. *Stahl und Eisen*, December 21, 3 pp. *c.* Discussion of the advantages of recovering the useful by-products (*coal-tar and ammonium sulphate*) when operating producer-gas plants. The figures in the article are taken from British practice.

Hydraulics

BARRAGES ET SYPHONS AUTOMATIQUES. *La Technique moderne*, December. 1½ pp., 5 figs. *b.* Description of an *automatic dam* for maintaining the water at a mathematically constant level independent of variations in the supply of water.

TURBINANLAEGGET VED ADAMELLO. *Elektroteknisk Tidsskrift*, December 7. 3 pp., 6 figs. *b.* Description of the *water turbine installation* in Adamello (Italy).

HOCHDRUCK-FREISTRAHLTURBINEN. *Der praktische Maschinen-Konstruckteur.* December 7. 2 pp., 1 sheet of drawings. *b.* Discussion of the *free-jet turbine*, its advantages, principles of construction, and adaptability for high speeds.

L'USINE HYDRO-ÉLECTRIQUE DE BEAUMONT (Izère), M. Gariel. *Le Génie Civil*, December 9. 4 pp., 7 figs. and 1 sheet of drawings. *b.* Description of the *hydro-electric plant* at Beaumont, Izere France, containing drawings of a *turbine speed governor*, Neyret-Brenier system.

COMPTEUR À DISQUE POUR EAU CHAUDE, SYSTÈME SIEMENS ET HALSKE. *Le Génie Civil*, December 2. ½ p., 1 fig. *b.* Description of the Siemens and Halske *hot water meter.*

DIE WASSERDRUCKMOMENTE DER DREHSCHAUFELN VON ZENTRIPETAL FRANCIS-TURBINEN, Prof. R. Camerer. *Zeits. des Vereines deutscher Ingenieure*, December 2. 9 pp., 21 figs. *b.* Description of an experimental and a theoretical method of determining the *moments of water pressure in the wheel-vanes of centripetal (inward flow) Francis turbines*, showing that such moments can be predetermined theoretically with sufficient accuracy.

DIE NEUE HOCHDRUCKTURBINEN- UND PUMPENANLAGE DES ELEKTRIZITÄTSWERKES BERGAMO. *Der praktische Maschinen-Konstrukteur*, December 21. 1 p., 1 table of drawings. *b.* Description of the general installation of the *hydro-electric plant* at Bergamo.

Internal Combustion Engines

*DIE GASTURBINE. *Stahl und Eisen*, December 7. 1½ pp., 1 fig. and 1 indicator diagram. *b.* Extract from a paper read on the *Holzwarth-Junghans gas turbine*, by H. Holzwarth, before the German Society of Naval Construction.

NEUERE ROHÖLMOTOREN, Ch. Pohlmann. *Dinglers Polytechnisches Journal*, December 16. 2 pp., 8 figs. *b.* Description of the *Diesel motor* built by the Aktiebolaget Diesels-Motorer in Stockholm.

D.A.C.-SCHIFFSZWEITAKTMASCHINE. BAUART DIESEL, J. Vollmer. *Die Gasmotorentechnik*, December 16. 7 pp., 10 figs. *b.* Description of a *two-cycle marine motor* of the Deutsche Automobil-Constructionsgesellschaft, by J. Vollmer, chief engineer of the company. The machine has an interesting system of *cylinder cooling* (air). Separate cylinders with their connections are all made exactly alike, so that the same "cylinder sets" can be used for two, four, etc., cylinder engines.

GROSS-OELMOTOR. *Stahl und Eisen*, December 7. ½ p., 1 fig. *b.* Extract of a paper read by Prof. H. Junkers before the German Society of Naval Construction on the construction of a *large (1000 h.p.) oil motor.* His motor has four plunger pistons which move in pairs in opposite directions in two cylinders. This makes the construction of the cylinders comparatively simple, but requires a somewhat complicated crank mechanism. The author claims for pistons running in opposite directions the following advantages: (*a*) simple valve gear by slots in the cylinder walls and pistons, an effective cooling of the cylinder walls being produced at the same time by the entering air, which allows a higher output for given dimensions of cylinder, and is also of value for the safety and economy of operation of the machine; (*b*) the engine bedplate is not called upon to transmit cylinder pressures; (*c*) reduction of reaction of pressures exerted by the masses to very small amounts.

Machine Shop

FABRICATION ET MODE D'EMPLOI DES MEULES D'ÉMERI, F. H. *Le Génie Civil*, December 9. 1½ pp. *c.* Extract from a paper read by W. Herminghausen at a meeting of German foundrymen, on various substances used for *abrasive wheels*, and methods and cost of using them, giving some practical rules on that subject based on materials obtained from the principal German manufacturers.

WARUM SOLL MAN SEINE GUSZCHARGEN NACH ANALYSEN UND NICHT NACH DEM BRUCHAUSSEHEN DES ROHEISENS GATTIEREN? Pfeiffer. *Gieszerei-Zeitung*, December 1. 2 pp. *h.* Second and last of two articles discussing the necessity of determining by analysis the presence and amount *of impurities in cast iron,* and not relying on the appearance of fracture alone.

*TRAITEMENTS THERMIQUES ET MÉCANIQUES DES MÉTAUX À L'ATELIER, F. Robin and P. Gartner. *Revue de mécanique*, November 30. 14 pp., 4 figs. *h.* Discussion of the theory and practice of *annealing* of various kinds of steel, iron, bronze and brass.

DIE HERSTELLUNG DES SCHMIEDBAREN GUSZES (TEMPERGUSZES) IN THEORIE UND PRAXIS, M. Lamla. *Gieszerei-Zeitung*, December 1. 3 pp. *A.* One of a series of articles on the production of *malleable cast iron.*

Mechanics

DÉFINITION GÉNÉRALE DE L'ELLIPSE D'ÉLASTICITÉ DES SYSTÈMES ARTICULÉS, B. Mayor. *Bulletin technique de la Suisse Romande*, December 10. 2½ pp. *cA.* The first of a series of articles. The author strives to define a geometric element in such a way that it would coincide with the definition of an *ellipse of elasticity* whenever such an ellipse can exist according to the usual definition, but which would at the same time be free of its restrictions, *i.e.*, not limited to a triangled system free in its plane. The author makes use for this purpose of a special type of trilinear coördinates.

URSACHEN UND BERECHNUNG DER KRITISCHEN TOURENZAHL, Fritz Reuter. *Zeits. für Elektrotechnik und Maschinenbau*, December 7. 2 pp., 4 figs. *e.* Exposition of the nature and method of calculation of the *critical number of revolutions.*

EMBRAYAGES RÉCENTS. *Revue de mécanique*, November 30. 40 pp., 90 figs. *bA.* Description of recent gearing, with a list of more than one hundred articles on *gearing* printed in the *Revue de mécanique* during the last ten years, and covering practically every system that appeared during that time.

TRANSMISSION À DISTANCE DES MOVEMENTS DISCONTINUS SYSTÈME HERZMARK, Ch. Jacquin. *Le Génie Civil*, December 16. 2 pp., 5 figs. *b.* Description of a system of *transmission of intermittent motion* capable of transmitting not only a rectilinear pull, but also a push.

ETUDE CRITIQUE DES DISTRIBUTIONS COMMANDÉES PAR CAMS, F. Carlès. *La Technique automobile et aérienne*, December 15. 3 pp., 6 figs. *h.* Theoretical investigation of *cams* for valve gears.

ETABLISSEMENT DU GRAISSAGE DANS LE MOTEUR ET LA TRANSMISSION, A. Guéret. *La Technique automobile et aérienne.*. 7 pp., 6 figs. *h.* Discussion of the principles underlying correct arrangement of *lubrication.*

Pumps

AUTOMATISCHE PRESZLUFT-SCHWIMMERPUMPE. *Der Bergbau*, November 16. ½ p., 1 fig. *b.* Description of a self-starting pump lately placed on the market in Germany, for use in places which have to be kept dry but where water may appear unexpectedly in not very large amounts. The principle of the pump is as follows: The water runs through an inlet orifice into a float, which sinks by gravity, closing the inlet orifice, and lets in compressed air which forces the water out into the delivery pipe. When the float is emptied it rises, and the operation is repeated.

Refrigerating Machinery

EINE AETHYLCHLORID-KÄLTEMASCHINE, R. Plank. *Zeits. für die gesamte Kälte-Industrie*, December. 1½ pp. Mr. Zimmerman demonstrated before the Society of Oxygen and Nitrogen Industries, November 2, 1911, his *ethylchloride* (C_2H_5Cl) *refrigerating machine.* The machine was very crudely made, but in three tests gave the following results of cold produced per h.p. hour:

	Cal. per German h.p	B.t.u. per American h.p.
Test 1	1,820	8,338
Test 2	1,610	7,370
Test 3	2,555	11,715

The curve of ethylchloride is such that a vacuum must be maintained; it does not attack metals, requires no lubrication, is not poisonous, solidifies at about —100 deg. cent. (—148 deg. fahr.), is not readily absorbed by water, burns, but does not explode; present price 350 M. per 100 kg. (about $0.39 per lb.), but probably will soon be reduced by one-half this amount.

The great objection to the possibility of such machines being built in large sizes is the large cylinder required, the cylinder volumes for different refrigerating substances being in the following ratio: $CO_2 : NH_3 : SO_2 : C_2H_5\,Cl = 1 : 5.87 : 15.2 : 37$.

DIE 13. HAUPTVERSAMMLUNG DER SCHIFFBAUTECHNISCHEN GESELLSCHAFT, O. Flamm. *Schiffbau*, December 27. 2½ pp. *g*. By a steam jet of high velocity in a jet refrigerating machine designed by Prof. Josse, of Charlottenburg, water vapor is drawn off from a space of very low pressure (about 0.006 kg/qcm, or 0.085 lb. per sq. in.), and evaporation of water produced. This leads to fall of temperature, and Prof. Josse has shown slides of his machine which, without any moving parts, produces a temperature of —17 deg. cent. (+1.4 deg. fahr.).

UEBER DIE BEKÄMPFUNG HOHER TEMPERATUREN IN BERGBAU, Dr. Dietz. *Zeits. für die gesamte Kälte-Industrie*, December. 2 pp. *f*. According to German law, the working day for men in mines where the temperature is higher than 28 deg. cent. (82.4 deg. fahr.) is limited to six hours. It is therefore an important problem to *keep the temperature in deep mines as low as possible*. This cannot be done by ventilation alone because too violent ventilation is apt to increase the danger of explosions, and put out the safety lamps. Installation of steam-driven refrigerating machinery under ground is inconvenient because the refrigerating liquids are of such a nature that, in case of accident, their spread in the mine would be extremely dangerous. To have the machinery above ground would not do either, owing to the difficulty of having vertical piping some 700 m. (2300 ft.) long stay airtight with 80 atmospheres pressure. The author recommends, therefore, the use of a *turbine-driven cold air machine*. It does not appear, however, that such a machine has ever been put on the market.

VERBESSERTE CO_2 EXPANSIONS-KÄLTEMASCHINE, Ludwig Horst. *Zeits. für Sauerstoff und Stickstoff-Industrie*, December. 5 pp., 1 fig., 4 diagrams. *b*. Description of an improved *refrigerating machine using carbon dioxide* in the form of a gas in the expansion cylinder, and discussion of principles underlying the use of CO_2 in refrigerating machinery.

Safety Appliances

INSTALLATIONS DE SÛRETÉ POUR LA MANUTENTION DES LIQUIDES INFLAMMABLES, APPAREILS MARTINI ET HUNEKE, M. François. *Le Génie Civil*, December 9. 4 pp., 9 Figs. *b*. Description of the Martini and Huneke *apparatus for safe storage of inflammable liquids*, particularly hydrocarbons. The inflammable liquid is protected from contact with air by an inert gas under pressure, which also serves to drive the liquid out of the vessel as soon as the cock is opened, the apparatus being so arranged that should a leak occur anywhere, the liquid is relieved of its pressure, and does not flow, thus making an explosion impossible.

Steam Engineering

NOUVELLES MACHINES À VAPEUR. *Bulletin technique de la Suisse Romande*. 3 pp., 12 figs. *a*. Comparison of Stumpf *straight-flow steam engines* with van der Kerchove engines, and attempt to show that the success of the first is due not to the use of the principle of straight flow, but to the presence of certain constructive details which were used long ago in the van der Kerchove engines. The data on which the article is based have been published before.

Ergebnisse der Abnahmeversuche einer Z-M.-Gleichstrom-Dampfmaschine, Karl Beneke. *Zeits. für Dampfkessel und Maschinenbetrieb,* December 15. 4 pp., 10 figs., 4 tables, of which 3 are data sheets of tests. *bc.* Description of an improved *straight-flow steam engine,* and data of a test of it.

Der Lollar-Gegenstrom-Gliederkessel. *Der praktische Maschinen-Konstrukteur,* December 21. 2 pp., 7 figs. *b.* Description of the Lollar counter-current sectional *boiler* for central heating. The boiler sections have such a shape that when put together, ducts for the passage of the gases of combustion are formed between them. There is no built-in connection between the boiler and smoke stack, the gases of combustion being simply led off to the stack from the furnace by a smoke tube. All the smoke tubes are placed on one side of the boiler.

Neuerungen im Dampfkessel und Feuerungsbau. *Schweizerische Bauzeitung,* November 18. 6 pp., 9 figs. *bc.* Description of *underfed furnaces* manufactured in Switzerland, and data from tests of same.

*La régulation d'une turbine alimentée en vapeur à haute et basse pression par un accumulateur Harlé. *Le Génie Civil,* December 2. ½ p., 1 fig. *b.* Description of the Harlé *accumulator for regulating the supply of steam* to a turbine working simultaneously on exhaust steam from other engines, and live steam from a boiler.

*Eine neue Ueberhitzerkonstruktion. *Der praktische Maschinen-Konstrukteur,* December 7. 1 p., 4 figs. *b.* Description of a new *superheater.*

Théorie du tube manométrique. *Revue de mécanique,* November 30. 7 pp., 4 figs. *c.* Mathematical determination of *the deformation of the tube in a Bourdon manometer,* and its relation to the indication of the manometer needle. The article is based on an earlier article in the *Zeits. des Vereines deutscher Ingenieure.*

Sur le tirage rationnel des générateurs de vapeur, J. Izart. *La Technique moderne,* December. 4 pp., 9 figs. *bh.* Continuation of the article (abstracted in The Journal last month) on rational *draft for boiler plants.* Description of systems used in France, in particular draft by ejector.

*Ueber Methoden zur Verhütung und Entfernung des Kesseleinsatzes, W. Dahse. *Zeits. für Dampfkessel und Maschinenbetrieb,* December 8. 1½ pp. Discussion of various methods of preventing the formation and removal of *scale in boilers.*

Aufstellung besonderer Motoren für Lichtmaschinen. *Elektrotechnik und Maschinenbau,* December 10. *f.* Article based on K. Hauck's article in the *Zeits. der Dampfkesseluntersuchungs- und Versicherungs-Gesellschaft*, September. The author is opposed to the practice of *driving the dynamo for lighting* a factory from the main steam engine rather than *from a separate engine.* Apart from variations in the intensity of light due to variations in the load on the engine, the author points to steam losses due to underloading such an engine when the lighting circuit is not in use. Two indicator diagrams show that an underloaded engine used 33.4 kg. per h.p-hr., while it ought to have used only 21 kg. per h.p-hr. (73.5 lb. against 46.2 German h.p., or 84 lb. against 55 lb. per American h.p.), involving an increase of cost of operation which would amply pay for an installation of separate engines, one for doing the main work of the factory, and another for driving the lighting dynamo.

CHLORIDE IM KESSELSPEISEWASSER, E. E. Basch. *Technische Rundschau*, No. 46, from extract in *Braunkohle*, December 15. *f. Magnesium chloride in boiler water* is one of the most powerful corrosive agents, attacking the boiler plates especially at the water line where the rise and fall of water afford the time for the deposition and decomposition of salts, and subsequent moistening of the affected surface. To make magnesium chloride harmless, the author recommends the use simultaneously of lime and soda, whereby magnesium chloride is converted into magnesium hydroxide.

OBSERVATIONS ET FORMULES RELATIVES À L'ÉCOULEMENT DES FLUIDES ÉLASTIQUES, Maurice Leblanc. *La Lumière électrique*, December 16. 5 pp., 5 figs. *ch.* Investigation of the flow of elastic fluids in which the author shows that a steam jet escaping from a nozzle at high velocity possesses a sort of individuality of its own, and does not necessarily take the form of the passage through which it is led. The article is to be continued and a fuller abstract will be given next month.

*ABWARMEVERWERTUNG BEI DAMPF-UND VERBRENNUNGSKRAFTMASCHINEN, Dr. Deinlein. *Zeits. des Bayerischen Revisions-Vereines*, October 15, from extract in *Elektrotechnik und Maschinenbau*, December 24. *a.* The author shows by tables that, as regards total *utilization of heat*, the steam and internal-combustion engine are about equal when the waste heat is also utilized. For 100,000 W.E. (397,000 B.t.u.) in fuel put into the engine, a steam engine with 70 per cent boiler efficiency will give 67 to 68.6 per cent total efficiency, and with 80 per cent boiler efficiency 76.5 to 78.1 per cent total efficiency, these figures covering engines working with saturated or superheated steam, non-condensing or condensing. Corresponding values for internal-combustion engines are 75 to 78 per cent. These figures presuppose, however, utilization of all the waste heat, and the author goes on to show that such utilization is really limited. With steam engines steam of any pressure desired, up to that in the boiler, can be taken from the engine, and water heated by it to any temperature up to that of saturated steam, while with internal-combustion engines water can be heated practically only up to 100 deg. cent. (212 deg. fahr.), and even that in small amounts. In general, where heating is required, a steam engine must be considered first, and where it is not required, an internal-combustion engine.

Umlegung eines Dampfschornsteins. *Tonindustrie-Zeitung*, December 21. Description of *dismantling* a 30-m. (98-ft.) high *smoke-stack* without the use of explosives, the main problem being to make the stack fall in a given direction. Part of the foundation on the side where the stack was required to fall was taken out and carefully replaced by strong wooden props; petroleum oil was then poured over them, and the props set on fire. The area covered by the falling bricks was 35 m. by 9 m. (115 ft. by 29 ft.).

*Untersuchungen über das allgemeine Verhalten des Geschwindigkeits-Koeffizienten von Leitvorrichtungen des praktischen Dampfturbinenbaues, Paul Christlein. *Zeits. des Vereines deutscher Ingenieure*, December 16. 9 pp., 8 figs., 19 curves. *h.* Investigation of conditions under which flow takes place, and losses occur, in nozzles and distributors of steam turbines now in use, based on experiments made in the mechanical laboratory of the Charlottenburg Technical Institute, with particular regard to the relation between velocity of flow and efficiency.

1500 P. S. Dampf-Generator von Friedr. Krupp A. G., Germaniawerft. und den Siemens-Schuckert Werken, Berlin. *Zeits. für Elektrotechnik und Maschinenbau*, December 13. 2 pp., 2 figs. and 1 sheet of drawings. *b.* Description of a *Zoelly* 1500-*h.p. turbine* built by the Friedr. Krupp Co.

Strength of Materials and Testing of Materials

La résistance à l'écrasement des fers aciers et alliages, F. Robin. *Bulletin et comptes rendus mensuels de la Sociéte de l'industrie minérale*, August-December. 425 pp. *b.* Investigation of *resistance to crushing* of steel as a function of temperature.

Ueber excentrisch gedrückte Stäbe und über Knickfestigkeit, Muller-Breslau. *Der Eisenbau*, December. 12 pp. *eA.* Theoretical investigation of the *behavior of bars* under pressure applied eccentrically and of resistance to axial compression.

Beitrag zur Biegungslehre, Otto Mohr. *Der Eisenbau*, December. 5 pp., 10 figs. *chA.* Application of Prof. Mohr's method of solving problems on deformations of elastic bars to such problems as the derivation of the fundamental equation for the calculation of continuous *beams*, pressures at the supports of beams with fixed ends having a polygon or curved cross-section, and stresses and deformations in bars fixed at one end, or having more complicated systems of support.

Versuche mit Alluminium geschweiszt und ungeschweiszt, bei gewöhnlicher und höherer Temperatur. *Zeits. des Vereines deutscher Ingenieure*, December 2. 3 pp., 3 figs. *h.* Data on strength of aluminum bars welded, hammered, annealed, etc.

Versuche mit einem autogen geschweissten Blechbehälter ausgeführt von der Firma Gebr. Sulzer, Winterthur. *Acetylen*, No. 22. 2½ pp., 7 figs. *b.* Description of tests made by the above-named concern of a plate tank having an *autogenously welded cylinder cover*. Rupture occurred at a pressure of 83 atmospheres.

Les chemins de fer du Brésil, Lionel Wiener. *Revue générale des* *chemins de fer*, December. 30 pp., 12 figs. *bc*. Description of railway construction in Brazil. Contains data on the *strength of Brazilian stone and timber*.

MACHINE ÉLECTRIQUE POUR L'ESSAI DES MATÉRIAUX. *La Revue électrique*, December 8. Description of an *electric testing machine* invented by Gisbert Kapp for long and often-repeated tests of materials.

APPAREIL SIMPLIFIÉ, SYSTÈME STERN-SONNEBORN, POUR L'ESSAI DES HUILES DE GRAISSAGE. *Echo des mines et de la métallurgie*, December 21. 1 fig. Description of an *apparatus for rapid testing of lubricating oils*. The oil is atomized in air or steam, and the mixture forced into a cylindrical box with two concentric helicoids inside, one going up and the other down. The mixture enters the box through an orifice at the bottom, passes up one helicoid and down another, and finally escapes, leaving in the serpentines of the instrument a deposit which by its appearance and amount shows the quality of the oil.

ERGEBNISSE VON SEILPRÜFUNGEN. *Der praktische Maschinen-Konstrukteur*, December 21. (From the last bulletin of the Royal Testing Laboratory at Gross Lichterfelde West, not yet received in this country). *c*. Data of endurance test of ropes. Ropes were laid over a pulley 5.3 cm. (2.07 in.) in diameter, a load of 20 kg. (44 lb.) placed at one end, and the other end connected with an eccentric in such a way that the rope made 15 movements per minute of 35 cm. (13.8 in.) each. The ropes tested had diameters: 0.5, 0.7, and 1.1 cm. (0.196, 0.275, and 0.42 in.). The ropes broke after from 7,200 to 18,000 movements when the ratio of the diameter of the rope to that of the pulley was 1 : 10, and after from 5,300 to 7,300 movements when this ratio was 1 : 7.5. This shows that the ratio ought not to be chosen too small. As regards the tendency of spiral steel ropes to twist, the amount or torsion in a rope 100 cm. (39.37 in.) long, at a load of 10 tons, or about one-eighth of the breaking load, was found to be 3.0, the torsion and elongation being approximately proportional to the load up to 35 tons, but at higher loads growing (particularly the elongation) more rapidly than the load. Ropes made by a special process out of 32, 120 and 192 piano wires had a strength equal only to about 30 to 55 per cent of the sum of strengths of the composing wires, the ratio being the less favorable the more wires the rope was composed of.

*OPYTY NAD VYRYVANIEM SVIAZEI I VYPOOCHIVANIEM PLOSKIKH STIENOK, M. V. Gololobove. *Bulletin of the Permanent Committee of the Conferences of Representatives of Russian Railroads*, No. 10. 12 pp., 18 figs. *c*. Results of experiments on tearing out of *bolts* and flexure of flat boiler walls, with reference chiefly to locomotive boilers.

Thermodynamics

CONTRIBUTION À LA THERMO-DYNAMIQUE DES GAZ, Charles Beer. *Revue universelle des mines*, No. 3. 48 pp. *ch*. Theoretical investigation in thermodynamics of gases, starting from the following two principles: (*a*) the temperature is proportional to the number of oscillations of molecules per unit time; (*b*) the quantity of heat in a body is represented by the increase of molecular kinetic energy of the body. The aim of the author is to show the connection between the production of heat and universal gravitation. (An article devoted to the same subject was published by H. C. Marx in *Die Turbine*, March 20, 1911, under the title "Gravitation und Wärme").

Ueber die Molekularwärme des Wasserdampfes, Herbert Levy. *Berichte der deutschen Physikalischen Gesellschaft.* 2 pp. *h.* Notice of a new investigation of the *specific heat of steam* containing a table of some of the new values (very close to the generally accepted ones). The new investigation is claimed to show, among other things, that, as the temperature rises, the isobars of steam tend to converge in a common line.

Der Wärmeübergang im Kreuzstrom, Wilhelm Nuszelt. *Zeits. des Vereines deutscher Ingenieure*, December 2. 3 pp., 5 figs. *e.* Investigation of the *flow of heat in a surface cooler* when the directions of the two streams of liquid are at right angles.

La transmission de la chaleur à travers les parois d'un local chauffé. *La Métallurgie*, December 13. 2/3 p. *hA.* Continuation of a series of articles by E. Mathieu (reprinted from the *Annales des travaux publics de Belgique*) comparing various methods of estimating, and data on, the *transmission of heat through walls and windows of houses.*

Die spezifische Wärme C_p der Luft bei Zimmertemperatur und tiefen Temperaturen, Karl Scheel and Wilhelm Heuse. *Physikalische Zeits.*, December 1. 2 pp., 1 fig. *h.* (Same article in *Berichte der Deutschen Physikalischen Gesellschaft*, No. 21.) The authors have redetermined the specific heat of air by Barnes and Callendar's method of continuous calorimetry, and have found the following values for dry atmospheric air, free of carbon dioxide, under atmospheric pressure:

Temperature (deg. cent.)	$\frac{\text{Watt-seconds}}{\text{g. deg.}}$	$\frac{\text{g. calorie}_{15}}{\text{g. deg.}}$
+20	1.009	0.240
−78	1.019	0.243
−183	1.058	0.253

Miscellaneous

Niveau de précision.. *Portefeuille économique des machines*, December 2½ pp., 5 figs. *b.* Description of a *level*, Leneven system simplified by H. Morin, for exact levelling, e. g. of shafting. Its chief parts are two vessels connected by a flexible rubber tube; each vessel contains a liquid, and is provided with a little rod, the point of which is brought in contact with the surface of the liquid; a graduated scale (with a vernier) shows the distance between the base of the vessel and the upper surface of the liquid, the difference in reading of the scales in the two vessels indicating the difference in level of the surfaces on which the vessels are standing.

Betrieb und Organisation eigener Patentenbureaus in Maschinenfabriken, Th. Schuchart. *Technik und Wirtschaft*, December. 12 pp., 9 figs. (forms of registration cards, etc.). It has been found in Germany that it pays even a medium-size machine factory to have its *own patent bureau.* The article describes the installation and methods of work of such a bureau in a fairly large German factory (Thyssen & Co., Mühlheim, Ruhr).

CHARGEMENT AUTOMATIQUE POUR CAMION AUTOMOBILE. *La France automobile et aérienne*, December 2. 2 pp., 4 figs. *b.* Description of a device for *loading an automobile truck* by its own power. The truck is provided with a small jib and a transmission consisting of a toothed segment on the jib and a screw-spindle engaging with it and receiving its power by an ordinary gear transmission from the motor of the truck.

L'OUTILLAGE TECHNIQUE ET PRATIQUE DU DESSINATEUR, J. Escard. *Revue de mécanique*, November 30. 24 pp., 48 figs. *b.* Description of instruments and methods for the optical, mechanical and photographic *reproduction of drawings*, and discussion of the best arrangement of a *drawing-room.*

NEUE ENTSTAUBUNGSEINRICHTUNGEN AUF RHEINISCHEN BRAUNKOHLENBRIKETTFABRIKEN, *G. Polster. Braunkohle*, December 22. 7 pp., 6 figs. *b.* Description of various appliances for the *removal of dust* in lignite briquette factories in the Rhine province.

DIE NEUERE ENTWICKLUNG DER FÖRDERMASCHINENANTRIEBE UND DER SICHERHEITSVORRICHTUNGEN, A. Wallichs. *Zeits. des Vereines deutscher Ingenieure*, December 2. 5 pp., 34 figs. *b.* Discussion of the modern types of *winding machines* and safety appliances.

SELBSTSTÄTIGER TEMPERATURREGLER SYSTEM BRABÉE-FUESZ. *Gesundheits-Ingenieur*, December 2. 1½ pp., 6 figs. *b.* Description of the Brabée Fuesz (R. Fuesz in Steglitz b.Berlin, Germany) *temperature regulator* for steam and water heating. The regulation is produced by the change in the volume of a liquid (alcoholic) due to changes in temperature.

*EINHEITSFARBEN ZUR KENNZEICHNUNG VON ROHRLEITUNGEN IN INDUSTRIELLEN BETRIEBEN. *Stahl und Eisen*, November 30. *g.* Description of a uniform system of distinctive pipe coloring proposed for use in Germany.

ABSTRACTS OF ARTICLES

Untersuchungen an Ventilatoren, A. Johnen. *Zeits. für Elektrotechnik und Maschinenbau*, November 30. The following data were obtained from tests made on three fans, two of the mine type with 2 m. (6.56 ft.) and 1.40 m. (4.59 ft.) diameter of the impeller; and one a forge fan 0.50 m. (1.64 ft.) diameter of impeller:

Tests of the fan having the radius of the impeller 1 *m.* (3.2 *ft.*). The fan had the following dimensions: Outside radius of the impeller 1 m. (3.28 ft.), inside radius $r = 0.60$ m. (1.96 ft.), radial length of the vanes 0.40 m. (1.31 ft.), the angle enclosed by the outside element of the blade with the tangent to the circle at that point 135 deg., the inside blade angle at the suction pipe 45 deg. The area of a vertical directing surface of a vane is $f = 0.144$ qm. (1.55 sq. ft.), the number of r.p.s. of the impeller 4, and, therefore, the volume of air enclosed by the impeller is $Q_o = 2\pi [\frac{1}{2}(R + r)] fn = 6.28 \times 0.80 \times 0.144 \times 4 = 2.894$ cu. m. = 102.1 cu. ft. The theoretical loss of pressure is $\frac{\delta}{g} v^2$ where δ is 1.2 (average weight of air), g is the acceleration of a freely falling body in meters (9.81), and v^2 for the given ventilator, at 240 r.p.m., is found to be 631, so that h_o corresponds to a manometer pressure of 77.2 mm. (3.03 in.) of water. In Table 1 all the values are reduced to $n = 240$ r.p.m. For the normal section F of the suction port = 1.06 qm. (11.4 sq. ft.), the output of the steam engine was determined by indicator as $N_i = 48$ h.p., no-load $N_o = 15$ h.p., so that the fan took $N_u = 48 - 15 = 33$ h.p. The power in the motion of the air

$$N_a = \frac{Qh}{75} = \frac{22.520 \times 65.2}{75} = 19.58 \text{ h.p.}$$

and the efficiency of the fan referred to the steam engine is

$$\mu = \frac{N_a}{N_i} = \frac{19.58}{48} = 0.41,$$

and the air efficiency of the fan is

$$\eta = \frac{N_a}{N_u} = \frac{19.58}{33} = 0.59.$$

Table 2 gives indicator values with a ratio of transmission between the steam engine and ventilator as 1 : 6.

According to the investigations of Tresca, the ratio between the work used by the fan expressed in meter-kilograms and the third power of the number of revolutions of the driving engine, is approximately a constant, equal to about 0.05. The author gives a table containing 11 values of Tresca's ratio, all in the neighborhood of 0.05.

Mine fan with radius of impeller $R = 0.70$ *m.* (2.245 *ft.*). With $n =$ 400 r.p.m., a peripheral velocity $v = 29.3$ m. per sec. (96 ft. per sec.), theoretical manometer pressure $h_o = 105$ mm. (3.45 in.) of water and theoretical

TABLE 1 MINE VENTILATOR WITH RADIUS OF IMPELLER 1m. = 3.2 ft.

General Data of Tests

Section of Suction Port F		Air Volume Q per Sec.		Manometer h in Water		Ratio of Pressures $h:h_0$	Ratio of Volumes $Q:Q_0$
Qm.	Sq. Ft.	Cu. M.	Cu. Ft.	Mm.	In.		
0.17	1.86	3.100	109.2	47.1	.185	0.61	1.07
0.63	6.78	12.146	428.	54.2	.213	0.70	4.20
0.83	8.93	17.280	610.	63.2	.248	0.82	5.97
0.97	10.41	21.678	763.	72.0	.283	0.93	7.49
1.06	11.39	22.520	795.	65.2	.256	0.84	7.78
1.42	15.25	26.921	950.	51.9	.204	0.67	9.30
1.87	20.01	33.590	1175.	46.9	.184	0.61	11.60
2.73	29.4	39.110	1380.	29.6	.116	0.38	13.51

TABLE 2 MINE VENTILATOR WITH RADIUS OF IMPELLER 1 m. = 3.2 ft.

Mechanical and Air Efficiency

Number of Revolutions of		Total Power	No-Load Work of Steam Engine	Power taken by Ventilator
Engine n_1	Ventilator n	N_i	N_0	N_u
30	180	26.12	7.72	18.40
32	192	30.20	8.60	21.60
34	204	36.16	8.87	27.29
36	216	40.26	9.60	30.66
38	228	47.30	10.53	36.77
40	240	54.93	11.60	43.32
42	252	60.81	12.67	48.14
44	264	70.59	13.87	56.72
46	276	79.04	15.00	64.04
48	288	89.90	16.51	73.75
50	300	100.93	17.63	83.30

TABLE 3 MINE FAN WITH RADIUS OF IMPELLER 0.70 m. = 2.245 ft.

General Data of Tests

Section of Suction Port F		Air Volume Q per Sec.		Manometer h in Water		Ratio of Pressures $h:h_0$	Ratio of Volume $Q:Q_0$
Qm.	Sq. Ft.	Cu. M.	Cu. Ft.	Mm.	In.		
0.15	1.61	3.227	117.5	66.5	.262	0.63	2.17
0.47	5.06	11.615	409.5	89.2	.351	0.85	7.80
0.72	7.75	16.280	570.	73.4	.289	0.70	10.93
0.83	8.93	17.588	622.	65.0	.256	0.62	11.80
1.32	14.2	24.085	850.	47.8	.189	0.46	16.16
2.72	29.3	28.584	1006.	15.9	.062	0.15	19.18

output of air 1,490 cu. m. (42.6 cu. ft.) per sec. Table 3 shows the efficiency of this ventilator, the assumptions being the same as in Table 1.

HOLZWARTH-JUNGHANS GASTURBINE. *Stahl und Eisen*, December 7. The Holzwarth-Junghans gas turbine belongs to the type of explosion turbines with intermittently working explosion chamber. It consists (Fig. 2) of a number of explosion chambers, *A*, placed in a ring, and each provided with air-inlet and gas-inlet valves, a stop-valve on the way to the nozzle, and several high-tension sparking plugs, as well as expansion nozzle *B*, as close to the explosion chamber as possible, and rotor wheel *C*, with velocity staging. The cycle of work is as follows: In one explosion chamber after another the mixture is ignited; the stop-valve to the nozzle is opened by the pressure developed by the explosion, and the gases of combustion do their work in passing through the nozzle to the wheel. After the end of the expansion, the stop-valve to the nozzle is made to close slowly in order to allow the air entering through the air-inlet valve thoroughly to scavenge the combustion chamber, and effectively cool it as well as the nozzle and rotor wheel. As soon as the connection with the nozzle is cut off, the fuel is let into the combustion chamber, now filled with pure air, and the formation of eddies insures a thorough mixture. The cycle described is shown in the indicator-diagram (Fig. 1). The turbine constructed for experimental purposes for the inventors was of 1,000 h.p. (German, or 865 American h.p.), at 3,000 r.p.m., used power gas of 1,100 to 1,200 W.E. per cu. m. (124 to 135 B.t.u. per cu. ft.), and had 10 explosion chambers and a valve gear driven by the shaft *E*, receiving its power from the main shaft by a helical wheel transmission. The inventors have found that to have a "quiet" explosion which can be used with advantage in a "motor process," the combustion pressure must not exceed that which produces self-ignition, which is possible only with low initial temperatures.

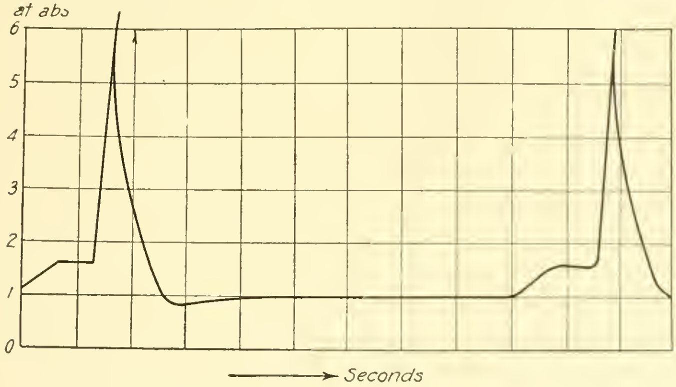

FIG. 1 HOLZWARTH-JUNGHANS GAS TURBINE INDICATOR DIAGRAM

TRAITEMENTS THERMIQUES ET MÉCANIQUES DES MÉTAUX À L'ATELIER, F. Robin and P. Gartner. *Revue de mécanique*, November 30. Annealing consists in heating a metal to a high temperature, but below that of fusion,

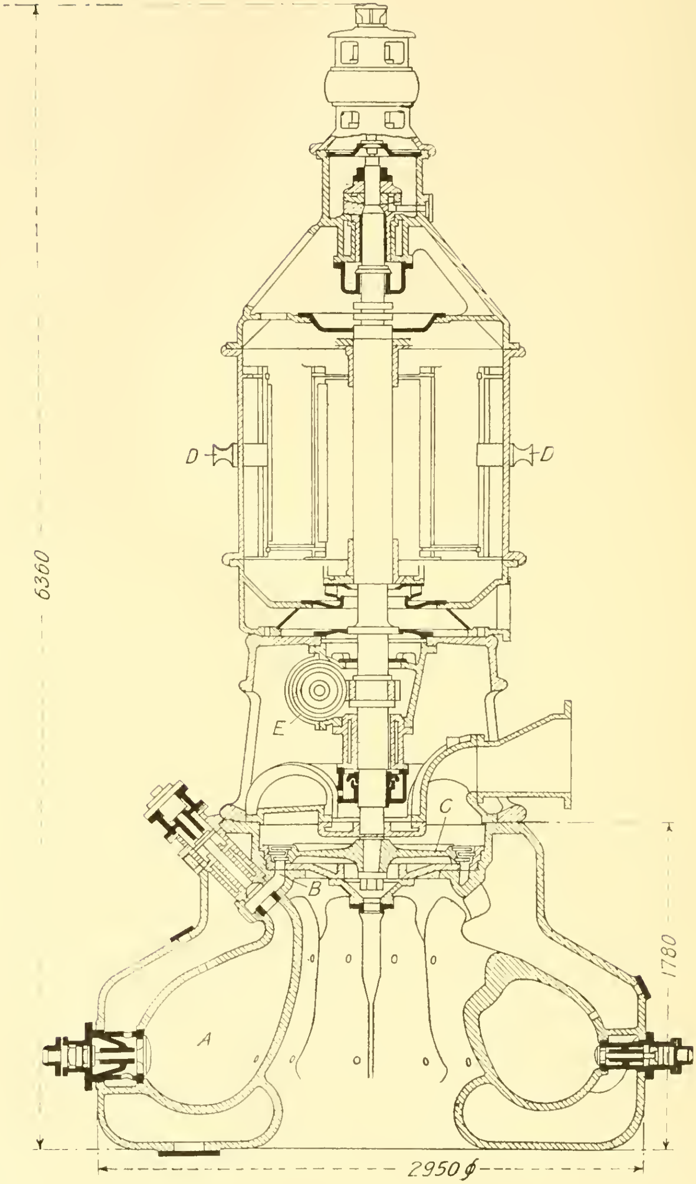

Fig. 2 Holzwarth-Junghans Gas Turbine

and then cooling it slowly down to the ordinary temperature so that it would attain its state of equilibrium and the mechanical properties belonging thereto. Annealing makes the constitution of the metal stable when cold; removes entirely the temper of the metal, which is the ability to maintain at ordinary temperatures a structure which is stable when the metal is hot; removes also the results of mechanical treatment, such as cold or hot hammering, and is often used to improve the qualities of a metal altered by heat or mechanical treatment which result in dangerous internal stresses, or too great crystallization.

Annealing of plastically deformed metal. A metal is said to be plastically deformed if it has undergone permanent deformations under a mechanical strain, which can be produced by forging, cold hammering, rolling. Hot plastic deformation, such as forging at 1,000 to 600 deg. cent. (1,832 to 1,112 deg. fahr.) for steel, 750 to 650 deg. cent. (1,382 to 1,202 deg. fahr.) for brass, changes the properties of metals less than cold, partly because hot metal lends itself better to internal changes generally, partly because subsequent cooling acts as annealing. Plastic deformation is not necessarily accompanied by visible changes in the structure; the strains break the crystals or deform them, and besides produce a sort of decrystallization which leads to changes in the properties of the metal, but the appearance of the elements does not change at all, and fine grain shown by microscope does not always indicate plastic deformation, because it could have been produced otherwise. Plastic deformation changes the chemical properties: drawn steel, brass and aluminum alloys after being subjected to it are more easily attacked by chemical agents than before; the heats of solution of steel in acids are also somewhat changed. It changes very materially the physical properties of metals, and increases the tensile strength as well as their limit of elasticity which in plastically deformed metal is inversely proportional to the elasticity in annealed metal. Hardness increases at the same rate as tensile strength, while the elongations in the tension tests fall off very rapidly, the malleability of the metal disappears, and its fragility increases. These variations are not proportional to the deformations; they grow rapidly at first for small deformations, then become slower and finally stop. At a comparatively slight deformation the limit of plastic deformation is reached, and the properties of the metal remain constant after that, no matter what the subsequent deformation may be. Impurities in metals raise the limit of plastic deformation quite noticeably; its limit varies with the temperature, and is generally lower at 500 or 600 deg. cent. (932 or 1,112 deg. fahr.) than at ordinary temperature.

Annealing brings the metal back to its normal state. In general, it acts gradually; the decrease of internal stresses is very slow at low temperatures, and it seems even that in some cases annealing during several minutes at 100 or 200 deg. cent. (212 or 392 deg. fahr.) makes even more prominent the effects of deformations. Then the decrease of plastic deformation goes on rapidly at first, but, as the annealing continues, it becomes slower, and seems limited to certain intervals of temperature. Finally, there is a zone of temperature at which crystallization by annealing is produced which grows with time and results in lower mechanical strength, in particular in decreases of elongations and reductions of area. This crystallization is facilitated by the presence of impurities or previous permanent set, though it may be produced without it, by the metal being subjected to a high temperature for a long time alone. Practical conclusions: To be complete, annealing must be between certain limits of temperature. A strongly plastically deformed metal, if left for some time alone, tends to recover and to lose its special properties; this is what is called spontaneous annealing, and recent investigations show that contact with annealed metal accelerates the return to equilibrium in plastically deformed metal, all that making such metal very unstable and unfit for service, especially in punched and stamped pieces.

If the annealed alloy possesses a point of transformation corresponding to a change in constitution, the metal ought to be heated a little above it, and then cooled slowly, the time of its being kept at the high temperature being rather short; if the alloy possesses no point of transformation, it is heated to the tempering temperature and slowly cooled. The following temperatures may be recommended for practical purposes:

	Deg. Cent.	Deg. Fahr.
Copper	650	1,202
Nickel	500	932
Zinc	150	302
Aluminum	450	842
Silver and gold	650	1,202

Influence of annealing on the grain of steel. If steel is heated up to its highest point of transformation, its original crystallization disappears, the new grain is the finest the metal can take for the given chemical composition, and the metal keeps this grain after cooling; with increase of carbon and manganese in steel the best temperature for annealing is lowered, together with the points of transformation. If steel is heated for the usual length of time at a temperature below the point of transformation, the size of the grains does not change. If the temperature rises substantially above the highest point of transformation, the structure becomes clearly crystalline, of a permanent character, and the higher the temperature at the beginning of the cooling the larger are the grains. At each temperature a certain time is necessary for the grains to attain their maximum size. Slow cooling allows the grains to grow, especially at the beginning; as a result, the higher the temperature of annealing and the slower the cooling, the larger is the grain. Impurities affect the size of the grain; phosphorus, especially in low carbon steels, makes them grow, while nickel, chrome and vanadium act the other way. With permanently set steel the action of annealing begins at about 400 deg. cent. (752 deg fahr.), and increases with the rise in temperature and length of heating. Complete annealing begins at the point of transformation between 750 and 800 deg. cent. (1,382 and 1,472 deg. fahr.), and continues to about 1,000 deg. cent. (1,832 deg. fahr.), after which crystallization begins. For iron and soft steel the temperature must be about 950 deg. cent. (1,742 deg. fahr.), for medium hard steel 850 deg. cent. (1,562 deg. fahr.), and for hard steel about 800 deg. cent. (1,472 deg. fahr.); time 20 to 30 min.

La régulation d'une turbine alimentée en vapeur à haute et basse pression par un accumulateur Harlé. *Le Génie Civil*, December 2. An interesting case of the use of a steam accumulator in connection with low-pressure turbines taking steam from high-pressure engines working intermittently, *e.g.*, in rolling mills, is when a turbine has to work simultaneously with high-pressure steam from a boiler, and low-pressure steam received from another engine through an accumulator. Fig. 3 shows the arrangement of the parts when a Harlé accumulator is used.

The inverted tank *A* of the accumulator moving in an annular body of water *K* is provided with a fixed cam disc *B* which operates, by means of the cam roller *b* and rod *t*, the two valves *C* and *C'*: one on the pipe *D* carrying low-pressure steam from the accumulator, the other on the pipe *D'* coming from the boiler, the valves being so interconnected that when one opens the other closes. The two admission valves *E* and *E'* are controlled by the governor *R*, and arranged so that *E'* begins to open only when *E* is already fully opened, in order that the high-pressure steam should act only as supplementary to the low pressure.

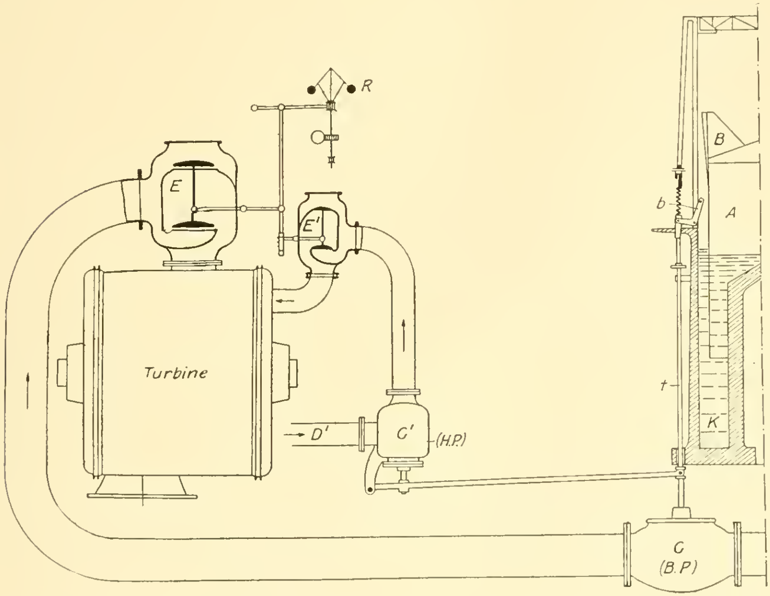

Fig. 3 Turbine using High and Low-Pressure Steam with the Flow of Steam regulated by a Harlé Accumulator

Eine neue Ueberhitzerkonstruktion. *Der praktische Maschinenkonstrukteur*, December 7. The fundamental conditions which a good superheater must satisfy, in the author's opinion, are a uniform distribution of steam over all the tube sections, and a sufficient division of the steam into fine jets. The greater the state of division of the wet steam in the superheater tubes, the better it takes up heat through the tube walls which are heated by the gases on the outside. The superheater shown in Figs. 4 and 5, is made of straight or bent tubes *b*, and has its admission collecting tubes *a* provided with nozzles cc_1, the purpose of which is to divide the steam entering into the superheater tubes *b*, *i.e.*, to give to it two different velocities. The arrangement of the nozzles can be such that the steam in one case passes close to the walls of the tube, and in another flows more along its axis, and thus breaks up the stream of steam with its water particles. The inventor of this superheater claims that, for a given

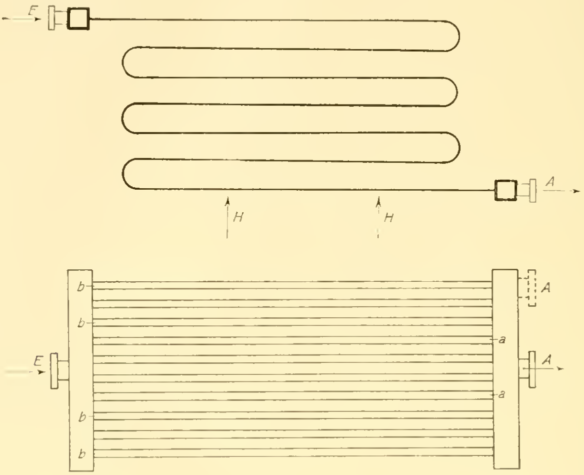

Fig. 4 Paul Koch Superheater

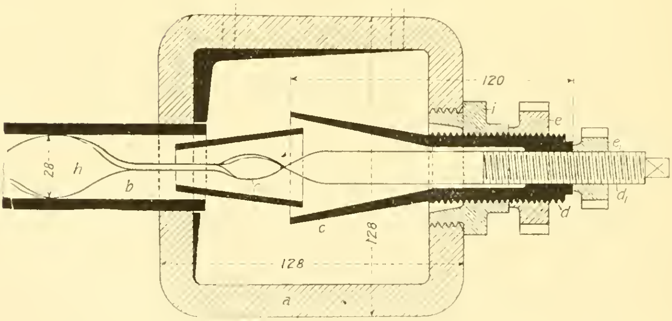

Fig. 5 Paul Koch Superheater showing Arrangement of Nozzles

area, it is 50 per cent more efficient than a superheater without such an arrangement of tubes and nozzles.

Ueber Methoden zur Verhütung und Entfernung des Kesseleinsatzes, Willy Dahse. *Zeits. für Dampfkessel und Maschinenbetrieb,* December 8 and 22. This article presents a summary of recipes for the prevention of scale in boilers patented in Germany at various times. The methods used are partly mechanical, partly chemical. In the majority of cases the latter are more efficient. The following methods are mechanical: *Bernhard's* process: 1 kg. (2.2 lb.) of soap is mixed thoroughly with an equal quantity of gall and potato starch at a high temperature, paste or glue being used as a cohesive. This boiler composition may be used in the form of tablets or of a liquid. The lubricating properties of the composition insure the preservation of surfaces coming in contact with the steam. Unruh adds to the boiler feedwater some potato amniotic liquor about 50 l. per 10,000 l. of water (½ of 1 per cent). A certain amount of muddy sediment is formed at the bottom which must be let off from time to time. To get rid of scale already formed *E. Marris* uses a disincrustant consisting of starch and paraffin or wax. The mixture is spread over the dry scale in a layer about 1 cm. thick (a little over ¹/₃₂ in.); the boiler is filled with water, and run for some days, during which time the scale breaks off in pieces. The starch is put in the mixture to prevent molten wax or paraffin and their gases from coming in contact with the surface of the boiler. After a few days the water is let out and the scale removed. *O. Lauffer* recommends for the prevention of formation and removal of scale the following composition: To 100 kg. (220 lb.) of tannin extract is added 1 kg. (2.2 lb.) of 25 per cent solution of ammoniacal salt, or of ammonium carbonate of equal concentration; this mixture is passed through cloth, cleared in filter presses, and brought up to density of 3 deg. Bé (1,023 American scale). It is kept at the temperature of 30 deg. cent. (86 deg. fahr.), and some rotting cheese is added to it, producing fermentation, and thereby eliminating all saccharine and oxidized products; there remain only combinations of tannin, very rich in hydroxyls, and efficient in the destruction of scale. The process of *Rüterbush* and *Bodstein* is based on the application of a petroleum emulsion: Grated quillaja bark or roots of common soapwort is moistened in a kettle by 30 per cent alcohol, left for 12 hours, and then diluted by 10 times its volume of water and heated. Solid particles are then separated out by filtration, and about 10 per cent of some inspissating substance, such as glycerin, starch or sugar, is added. Finally 10 parts of petroleum are added, little by little, in a thin stream, while the liquid is constantly stirred, and then the whole is left to cool completely. This emulsion is easily soluble in water, and can be kept for a long time without decomposition. *Smit* recommends for scale prevention a wash consisting of 1 kg. fish oil, 1 kg. horse fat, 1 kg. paraffin, 1 kg. white of zinc, 1½ l. (1.58 qt.) rain-water, 4 kg. graphite, 1 kg. lamp-black and 0.1 l. (0.1 qt.) carbolic acid. *Langrehr* suggests a wash consisting of 1 kg. graphite, 2 kg. milk and 20 kg. carbolic acid. *Kuhnert* claims to be able to prevent formation of hard scale by adding to the water ½ to 1-3 kg. (1.1 to 0.7 lb.) pumicestone for each qm. (10.76 sq. ft.) of water covered heating surface. *Becker* uses for the same purpose a mixture of 8 per cent ground pumicestone, 5 per cent powdered aluminum bronze and 87 per cent graphite. This mixture is said not only to prevent the formation of scale, and to remove scale already formed, but to remain in the boiler for a very long time, and to produce a polish on the boiler plates.

The following are chemical methods: *Doremus* introduces into the boiler potassium or sodium fluoride, hydrofluoric acid or cryolite and thus changes the scale into insoluble fluorides which form a precipitate, and can be removed by filtration. *Baudet* uses for the same purpose a mixture of 15 parts sodium hyposulphate, 10 parts rain-water, and 10 parts glycerin. *Schröder* adds sodium carbonate and magnesium oxide or hydroxide. *Bohlig* uses magnesium oxide or basic magnesium carbonate, and his method is said to be practical. *Bellanger* throws in a vessel, containing some 2 cu. m. (about 70 cu. ft.) water, 100 kg. (220 lb.) of hydraulic mortar or half that much cement, and the water is stirred until all the solid particles are suspended. Cement must be thrown in slowly. The liquid is then allowed to subside, and when the water has become clear it is decanted and the vessel, under constant stirring, is filled with fresh water. This is repeated until the hardness of the decanted water approaches that of fresh water, and then the deposit is dried and stored in sacks. This process frees it from soluble calcium salts. *Frank* adds to the water soluble soda glass until an alkaline reaction sets in, and then aluminum silico-fluorate up to a neutral or weak acid reaction. Soluble glass deposits the soluble salts of calcium, magnesium and iron, and aluminum silico-fluorate does the same for the cryoliths, etc. *Nieske* found that the addition of chrome salts prevents the formation of scale because the bicarbonates or sulphate of calcium pass into chrome salts, and easily settle down, leaving the boiler walls very clean.

Untersuchungen über das allgemeine Verhalten des Geschwindigkeits-Koeffizienten von Leitvorrichtungen des praktischen Dampfturbinenbaues, Paul Christlein. *Zeits. des Vereines deutscher Ingenieure*, December 16. It was pointed out lately that we know comparatively little about losses in different parts of the steam turbine, and cannot even answer the simple question, whether the losses increase or decrease with the increase of velocity. To investigate this, the author made tests in the mechanical laboratory of the Technical Institute at Charlottenburg.

In actual experience when steam flows out through nozzles or distributors it meets with various resistances which reduce its theoretical velocity w_0 to the actual velocity of efflux w, so that $w = \Phi\, w_0$, where Φ is the coefficient of velocity, and is equal to $\frac{w}{w_0} = 9.8 \frac{R\;1}{G w_0}$, R being the reaction pressure in kg., and G the weight of the flowing-out medium in kg. per sec., w in m. per sec., and in the direction of the geometrical axis of the nozzle or distributor. Since w_0 could be obtained from the theoretical expression $w_0 = 91.53 \sqrt{i_1 - i_2} = 91.53 \sqrt{\lambda}$ (where i_1 is the total heat of the steam at the entrance to the nozzle, and i_2 is the heat after frictionless adiabatic expansion to the back pressure p_2), to determine Φ it is necessary to find experimentally the values of R and G. The tests have given the following results:

Nozzle with obliquely cut end and free expansion (Fig. 6). Fig. 7 gives

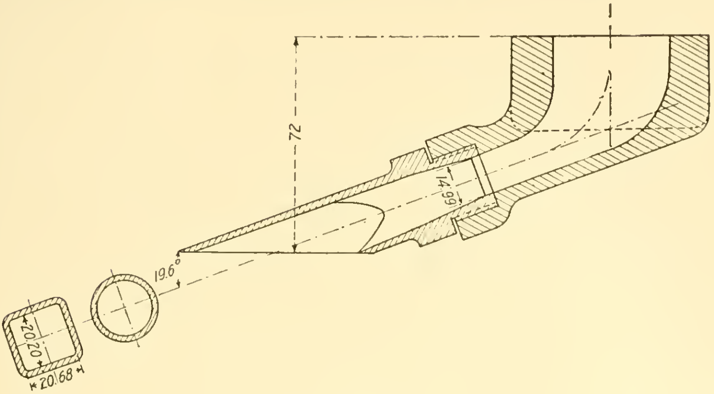

Fig. 6 Nozzle with obliquely cut End

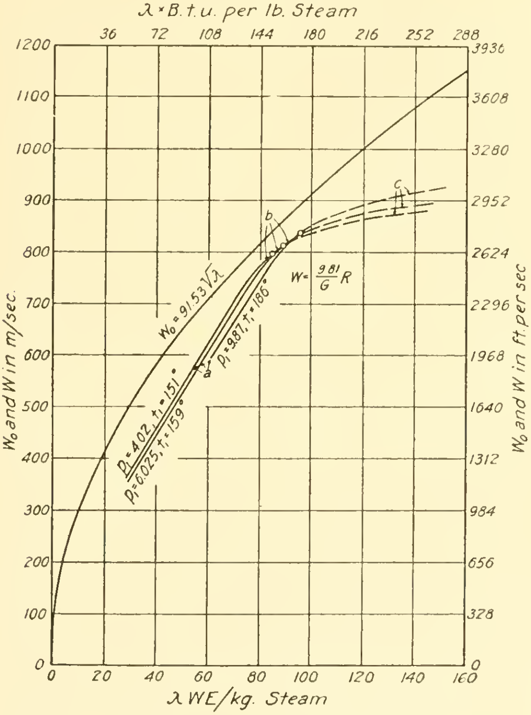

Fig. 7 Characteristic of the Nozzle shown in Fig. 6

as a function of the adiabatic loss of heat λ both the theoretical velocity of efflux $w_0 = 91.53 \sqrt{\lambda}$, and the actual velocity of efflux $w = \frac{9.81\ R}{G}$ determined experimentally. The curve $w = f(\lambda)$ can be divided into three parts: (*a*) branch *a* rapidly rising from *o*, and representing the action of the nozzle at incomplete expansion, or back pressure $p_2^1 > p_2$, it being assumed that the widening of the nozzle is made to correspond to the ratio $\frac{p_2}{p_1}$.

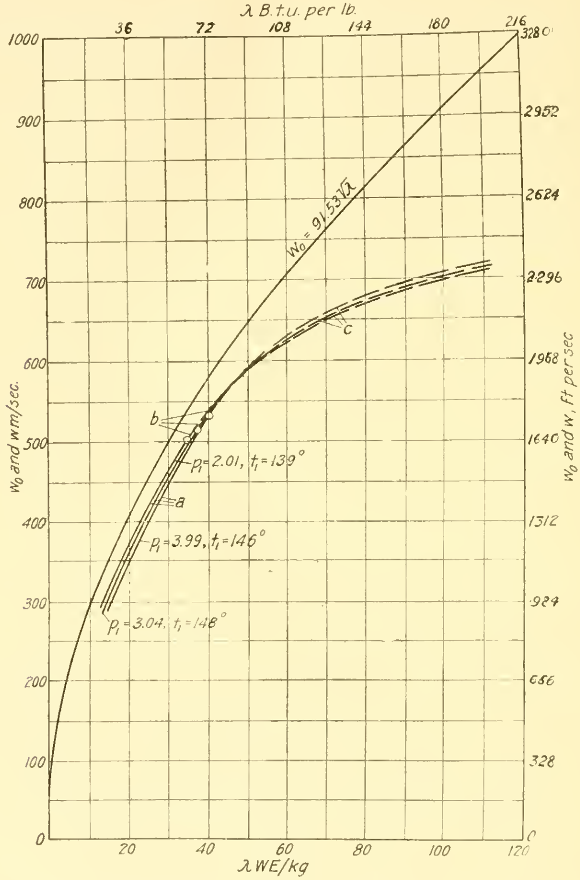

FIG. 8 CHARACTERISTIC OF A NOZZLE WITH PARALLEL WALLS

(*b*) the bend of the curve *b* for the action of the nozzle at complete expansion at $p_2^1 = p_2$, and in its immediate neighborhood; the curve *w* is very close to the theoretical velocity of efflux w_0, and the losses are very small, consisting of surface friction and internal friction between separate jets of the fluid; the efficiency of the transformation of energy, or the coefficient of velocity is here at its maximum. (*c*) the part *c* shows what happens when the widening of the nozzle is too slight, as compared with the ratio of pressures $\frac{p_2{}^1}{p_1}$. The whole curve can be considered as the characteristic of a nozzle, and shows clearly for the first time how all the outside influences affect the transformation of energy in a given nozzle.

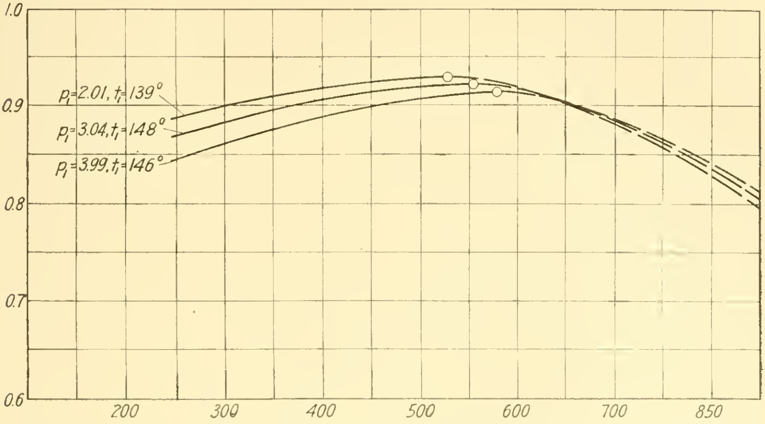

FIG. 9 CHARACTERISTIC OF THE SAME NOZZLE WITH DIFFERENT INITIAL PRESSURES

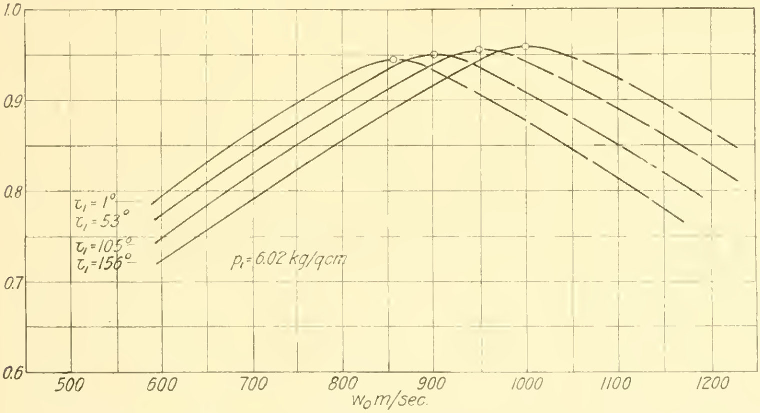

FIG. 10 CHARACTERISTIC OF THE NOZZLE SHOWN IN FIG. 6 WITH DIFFERENT DEGREES OF SUPERHEAT

As a particular case of a nozzle with a conical widening, *i. e.*, $\frac{F}{F_m} > 1$, the case of $\frac{F}{F_m} = 1$ may be considered, that is the ordinary nozzle with parallel walls. Fig. 8 gives the $w = f\ (\ \lambda\ )$ curve for this case. The part a shows the influence of the surface friction against the walls of the nozzle, and of the internal friction between separate jets of the fluid; the part b where the curve lies in close proximity to the theoretical curve $w_0 = f$

TABLE 4 DATA OF TESTS ON VELOCITY OF FLOW OF STEAM IN NOZZLES AND DISTRIBUTORS OF TURBINES

Angle of Lead, Deg. α	Axial Length, Mm.	Number of Passages	Material	Area up to the Smallest Cross-Section	Area from the Smallest Cross-Section to Outlet	Smallest Cross-Section of Nozzle ΣFm, Qcm.	Outlet Cross-Section ΣF, Qcm.	$\frac{\Sigma F}{\Sigma Fm}$	$\frac{d}{dm} = \sqrt{\frac{\Sigma F}{\Sigma Fm}}$	p_1 Kg/qcm	t_1 Deg. Cent.	t_1 Deg. Cent.
										4.02	151	8
19.6	72	1	bronze	rough	smooth	1.766	4.15	2.35	1.533	6.025	159	1
										9.870	186	7
										4.98	157	6
20.1	63	1	bronze	rough	smooth	2.461	5.002	2.035	1.427	3.02	138	5
										10.76	185	3
19.7	45	1	bronze	rough	smooth	0.5568	1.466	2.632	1.623	8.84	176	2
										5.94	160	2
										4.00	146	3
24.7	79	2	cast iron	rough	smooth	2.06	12.94	6.28	2.51	8.00	170	0.5
										4.98	158	7
20.8	75	2	bronze	best machined	best machined	3.584	4.284	1.185	1.087	3.00	144	11
										4.99	155	4
21.1	75	2	bronze	best machined	best machined	3.668	7.116	1.940	1.393	2.96	144	11

Test of Distributor

Angle of Lead, Deg. α	Axial Length, Mm.	Number of Passages	Material	Area up to the Smallest Cross-Section	Area from the Smallest Cross-Section to Outlet	Smallest Cross-Section of Nozzle ΣFm, Qcm.	Outlet Cross-Section ΣF, Qcm.	$\frac{\Sigma F}{\Sigma Fm}$	$\frac{d}{dm} = \sqrt{\frac{\Sigma F}{\Sigma Fm}}$	p_1 Kg/qcm	t_1 Deg. Cent.	t_1 Deg. Cent.
										2.01	139	18
21.6	75	3	cast iron with nickel-steel tips cast in	rough	rough	5.192	5.192	1	1	3.04	148	14
										3.99	146	2

(λ) shows the working of the nozzle at a velocity exceeding, within definite limits, the so-called critical velocity; the part c shows what happens when the velocity exceeds the critical velocity beyond stated limits, and a considerable expansion in free space occurs after the fluid leaves the outlet of the nozzle.

In Fig. 9 the theoretical velocities w_0 are used as abscissae, and the coefficients of velocities as ordinates. It shows the remarkable fact that *the efficiency of the transformation of energy in a nozzle is higher after the so-called critical velocity is exceeded,* contrary to now existing views.

Influence of superheat. The maximum coefficient of velocity is improved by superheating, all other conditions remaining as before, up to about 4 per cent, in proportion to the degree of superheating, as shown in Fig. 10. The author claims that as regards the maximum coefficient of velocity $\phi_{\max}$, apart from small (0.5 per cent) variations due to changes of initial pressure, it is increased from 1 to 2 per cent with increasing velocity w_0, the only exception to this being very small nozzles with a diameter of about 8 mm. (0.314 in.). The main point to which the author calls attention is that under correct conditions of work (*i.e.*, with a ratio of widening $\frac{F}{F_m}$ corresponding to the usual ratio of pressures $\frac{p_2}{p_1}$) the flow losses in the nozzle, all other conditions remaining unchanged, gradually decrease as the velocity increases. Table 4 gives the data obtained in the experiments.

OPYTY NAD VYRYVANIEM SVIAZEI I VYPOOCHIVANIEM PLOSKIKH STIENOK (Experiments on tearing-out of bolts and flexure of flat boiler walls), M. V. Gololobove. *Bulletin of the Permanent Committee of the Conferences of Representatives of Russian Railroads,* No. 10. Fig. 11 shows the arrangement used for these experiments. A copper sheet A (180 mm. x 180 mm. 7.1 in. x 7.1 in.) with a staybolt B wrapped in it was gripped in an iron frame made of two parts C and D. The upper part D was made of a flat sheet, 19mm. (0.75 in.) thick, with a square hole of 100 mm. (3.937 in.), equal to the average surface of a section of the furnace wall sustained by one stay. The two parts C and D were bolted together by four bolts E. The lower part C was provided with a special head to be placed into the grips of the testing machine; in the other pair of grips of the machine was placed the end of the staybolt B. This left a free square, 100 mm. (3.973 in.) on each side, out of which the testing machine tore out the stay. For these experiments sheets were taken 14, 10, 8 and 6 mm. (0.5, 0.39, 0.315 and 0.235 in.) thick, each with four threaded staybolts, out of which one staybolt had no head, and the rest had riveted heads of the following dimensions: (a) $h = 8$, $d = 42$ mm. ($h = 0.315$, $d = 1.65$ in.); (b) $h = 5$, $d = 37$ ($h = 0.195$, $d = 1.45$); (c) $h = 3$, $d = 31$ ($h = 0.118$, $d = 1.24$ in.). The sheet 14 mm. (0.5 in.) thick had three unthreaded staybolts with heads, and two threaded—one without head, and one with a normal head ($h = 8$, $d = 42$). This was done in order to determine experimentally the resistance to shearing offered by the head alone, when there is no threading to interfere. All the staybolts had the same diameters, 25 mm. (0.957 in.) in the threaded, and 22 mm. (0.865 in.) in the smooth part. The tables and curves give the results obtained in these experiments. The article is to be continued (main results of these experiments will be given with the second part).

EINHEITSFARBEN ZUR KENNZEICHNUNG VON ROHRLEITUNGEN IN INDUSTRIELLEN BETRIEBEN. *Stahl und Eisen*, November 30. (The same article is printed in the *Zeits. des Vereines deutscher Ingenieure*, December 2). Several important German societies (Society of German Engineers, Association of Mining Interests in the Upper Mining Districts of Dortmund, Association of German Central Heating Concerns and the Society of German Engineers-Inspectors) have worked out a uniform system of distinctive coloring for pipes in industrial plants. But few colors are used in order that the men can easily remember them; there is no time to consult a table of colors in case of accident. The colors must be clear and easily distinguishable. The following basic colors are proposed: Green for water, yellow for gas, blue for air, white for steam, black for tar, rose for lye, brown for oil, gray for vacuum, rose with red streaks for acids. A fuller indication of the contents of the pipes, pressure, temperature, impurities or admixtures is effected by a combination of the basic colors with strips of the following colors: Red stands for danger, black for impurity, white for presence of steam, green for presence of water. The direction of flow may be indicated, if necessary, by arrows. The same colors may be used in drawings, steam being indicated by fine double lines. The colors on the pipes should be indicated by securely attaching to the pipes small painted and enameled or varnished strips of iron 3 in. to 4½ in. wide.

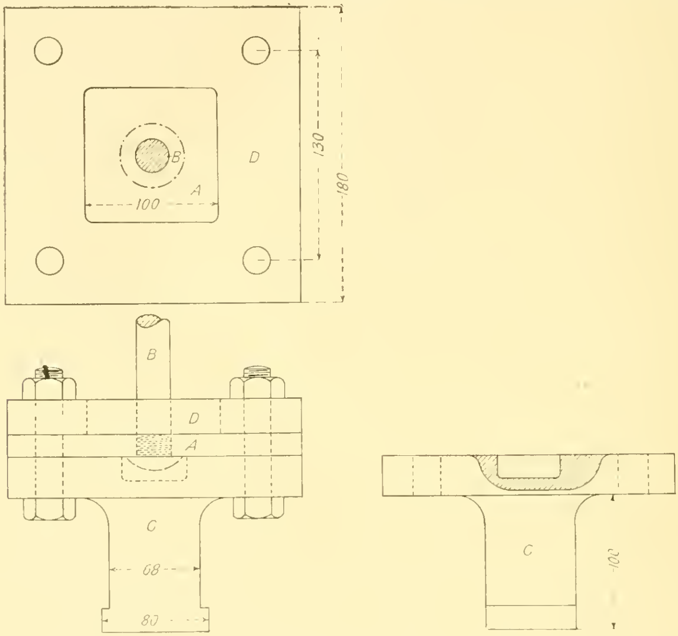

FIG. 11 STAYBOLT AND PLATE IN THE EXPERIMENT ON THE TEARING-OUT OF STAYBOLTS

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(XIV)

ARTICLES IN PERIODICALS[1]

Ausströmen von Gasen durch Düsen, Die, Georg Hamel. *Stahl und Eisen*, November 11. 3 pp., 4 curves. *e.*

On the flow of gases from nozzles.

Bituminous Gas Producer, New. *The Iron Age*, December 14. $1\frac{1}{3}$ pp., 3 figs.

Details and construction and gas purification of the Nordenson type developed by the Standard Gas Power Co.

Crude Oil Engine, A New. *The Engineer* (London), December 1. 1 p., 3 figs. *bfA.*

Two-cycle crude oil engine involving hot-bulb ignition, fuel injection direct into cylinder and crank case compression of air only. The possibilities of the two-cycle are not used to obtain reversal of direction of motion of the engine itself, a reversing gear being fitted.

Crude Oil Gas Producer, The Grine. *Power*, November 14. $\frac{2}{3}$ p., 1 fig. *b.*

Describes an outfit supplying gas to a 100-h.p. engine running practically at full load, 24 hours per day. The replenishment of the coke bed in generator is about 1/80 lb. per b.h.p-hr.

Diesel Engine, The Kind-Marine. *International Marine Engineering*, December. $1\frac{1}{2}$ pp., 4 figs.

General description of a reversing Diesel engine made by P. Kind & Co., Turin, Italy.

Diesel-Maschine der Maschinenfabrik J. E. Cristoph A. G. auf der Posner Ausstellung 1911, Ernest Neuberg. *Die Gasmotorentechnik*, November.

On the J. E. Cristoph Machine Works Co.'s Diesel engine as exhibited at the exposition of 1911, in Posen, Germany.

Engine, A New Gas. *The Engineer* (London), December 8. $\frac{1}{3}$ p., 1 fig. *bfB.*

Describes engines, 10 to 100 h.p., built by Ambrose Shardlow & Co., Ltd., Ealing Wks., Sheffield.

Engine, The Two-Stroke Cycle, R. G. Wells. *Engineering*, November 3. $3\frac{1}{3}$ pp., 14 figs. *abf.*

Describes the various types and their operation.

Engine, The Rayner Two-Stroke. *Power*, November 7. 1 p., 2 figs. *b.*

An effort to produce a sleeve-valve engine without infringing on the Knight patents. Description and details of engine.

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[1] Opinions expressed are those of the reviewer not of the Society. Articles are classified as *a* comparative; *b* descriptive; *c* experimental; *d* historical; *e* mathematical; *f* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

ENGINES, THEIR DESIGN AND APPLICATION, GAS, E. N. Percy. *International Marine Engineering*, December. 2½ pp.

Article continued from November issue.

GAS-ENGINE EXPERIMENTS, MECHANICAL COUNTER AND ELECTRICAL RECORDER FOR, John Eustice. *Engineering*, November 3. 1 p., 2 figs. *b.*

GASOLIN AUS NATURGAS, DIE GEWINNUNG VON. *Journal für Gasbeleuchtung und Wasserversorgung*, November 18. 2 pp. *def.*

The production of gasolene from natural gas.

MARINE DIESEL ENGINE PRACTICE, SOME IMPRESSIONS OF CONTINENTAL. *The Engineer* (London), December 8, 15, 22, 29. 7½ pp., 23 figs. *abfA.*

Notes and description of large two-cycle marine oil engines built by Carels Frères (December 8); eight-cylinder, submarine engine built by Maschinenfabrik, Augsburg-Nurnberg (December 15); Sulzer six-cylinder marine engines for the Italian mailboat Romagna (December 22); Schneider & Co.'s Sabathe, four-cylinder submarine engines (December 29).

MARINE OIL ENGINE, THE JUNKERS. *Engineering*, November 24. 3 pp., 12 figs. *b.*

Description and details of operation of a 200-h.p. engine and arrangement of a 1600-h.p. marine installation.

MOTEURS À PETROLE. *Revue de mécanique*, October 31.

———Carburateurs, G. Richard. 10 pp., 20 figs.

New types of carburetors: Bailey, Belleville, Bollee, Carter, Tolberth, Daimler.

———Diesel moteurs. 12 pp., 22 figs., 2 tables. *A.*

Describes Diesel motors of various types: Normand, Cavels & Schneider, Sulzer, Blackstone & Carter, Schiemann.

———Mises en train, G. Richard. 2 pp., 4 figs.

Arrangements of reversing gas engines. Types: Daimler, Sulzer, Remington.

———Moteurs Diesel à bord du petroleur Vulcanus. 2 pp., 5 figs.

Diesel motor on board S.S. Vulcanus. See also *The Engineer* (London), January 6, 1911.

MOTEURS À PETROLE, *Revue de mécanique*, November 30.

———Carburateurs. 11 pp., 45 figs.

Review of latest patents on carburetors.

NEUERE ROHÖLMOTOREN, Ch. Pöhlmann. *Dinglers Polytechnisches Journal*, November 4. 5 pp., 11 figs. *A.*

Describes new types of crude oil motors.

PEAT, POWER FROM. *The Engineer* (London), December 8. 1 p., 3 figs., 2 tables. *bdfA.*

Describes a successful 400-h.p. gas producer power plant at the factory of H. Robb, Portadown, using peat as fuel. This plant consists of two 200-h.p. gas producers, coke scrubbers, tar extractors, sawdust scrubber, exhausters and expansion box. This is claimed to be the only direct commercial utilization of peat working daily in the British Isles.

PRODUCER GAS. *The Engineer* (London), December 15. ½ p., 2 tables. *befA.*

Removal of dust and tar from producer gas by the dry or atmospheric method and the wet or water cooled method.

ROHOELMOTOREN DIESEL, NEUERE, Ch. Pöhlmann. *Dinglers Polytechnisches Journal*, December 23. 7 pp., 6 figs., 2 tables, 5 curves.

New type of crude oil motors, especially Diesel type.

TEER ZUM BETRIEBE VON DIESEL MOTOREN, VERWENDUNG VON, W. Allner-Dessau. *Journal für Gasbeleuchtung*, October 28. 10 pp., 24 figs., 3 tables, 16 curves. *A.*

Use of coal tar as fuel for Diesel motors.

THERMO-DYNAMIQUE DES GAZ, CONTRIBUTION À LA, Charles Beer. *Revue Universelle des Mines de les Métallurgie*, September. 47 pp. *e.*

Thermodynamics of gas.

TURBINE, THE EFFICIENCY OF THE GAS. *Engineering*, November 24. ⅔ p. *bc.*

From a paper read before the German Society of Naval Architects.

TURBINE, THE GAS, H. Holzworth. *Engineering*, November 24. 1⅓ pp., 1 fig., 2 curves. *b*.

Translation of paper before the Schiffsbautechnische Gesellschaft, Berlin, November 23, 1911.

VERBRENNUNGSMOTOREN IN ST. PETERSBURG 1910, DIE INTERNATIONALE AUSSTELLUNG, Alexis Bikoff and Georg von Doepp. *Die Gasmotorentechnik*, November. 4 pp., 5 figs., 4 tables, 1 curve. *b*.

On various internal-combustion engines at the International Exposition of 1910 in St. Petersburg, Russia.

GENERAL NOTES

SOCIETY FOR THE ADVANCEMENT OF EDUCATION IN THE SOUTH

The Society for the Advancement of Education in the South held its annual meeting, December 27–29, 1911, at Atlanta, Ga. The purpose of this society is to secure more exact and extensive knowledge of educational conditions and problems; more efficient union of educational forces; and more aggressiveness in advancing the cause of education. To further these ends some of the greatest national educators accepted invitations to speak before the meeting. The program also included papers and exhibits on recent conceptions of educational efficiency, education for the development of Southern rural life, industrial and vocational education in the South, agricultural education, rural sanitation, education for home life, education of adults, educational work of women's clubs, standardization of college education, recent criticisms of colleges, state inspection of elementary schools, adaption of education for life, the modification of the college curriculum to meet the demands of rural life, etc. An attractive feature of the meeting was a number of art exhibits by art dealers and artists. It consisted of a large number of carefully selected reprints and plaster casts of the great masters by the leading art dealers of the country. The exhibit also contained a number of paintings by Southern artists who are especially interested in developing art in the South.

NEW ENGLAND WATERWORKS ASSOCIATION

The annual meeting of the New England Water Works Association was held at the Hotel Brunswick, Boston, Mass., January 10, 1912. There were reports by the following committees: To look after and keep track of legislation and other matters pertaining to the Conservation, development and utilization of the natural resources of the country; To prepare a standard specification for fire hydrants; On uniformity of hose and gatenuts and direction of opening; On water consumption and statistics relating thereto; To collect information as to low water yields of catchment areas in New England, and at their discretion, outside of New England.

AMERICAN SOCIETY OF CIVIL ENGINEERS

The annual meeting of the American Society of Civil Engineers was held at the society house, New York, January 17 to 20, 1911, and the following papers were presented for discussion: Drainage and Foundations; Fillers for Brick and Block Pavements; Bituminous Surfaces; Uses of Bituminous Material in Penetration and Mixing Methods. The list of excursions was particularly interesting this year, including visits to the aqueduct shafts, the Grand Central Terminal improvement, subway work, Fourth Avenue, Brooklyn, Mount Prospect Laboratory, Brooklyn; and to the Bush Terminal, Brooklyn.

ENGINEERS SOCIETY OF PENNSYLVANIA

The Engineers Society of Pennsylvania held its annual meeting at Harrisburg, Pa., January 15, 1912. The convention was given over principally to the reading and discussion of the annual reports of the standing committees, and to a number of proposed amendments to the society's constitution. The subjects with which the committee reports dealt included public structures and buildings, water supply and sanitation, light and power, roads and highways, railroads and waterways, industrial education, conservation, telegraph and telephone communication, mines and mine safety, mineral lands, legislation and sociological problems relating to the engineering field.

WESTERN SOCIETY OF ENGINEERS

The annual meeting of the Western Society of Engineers, held in Chicago, Ill., January 10, 1912, was preceded by an excursion to the McCormick works of the International Harvester Co. In addition to the usual addresses by the retiring and newly-elected presidents, W. F. M. Goss, Mem. Am. Soc. M. E., and Judge Marcus Kavanaugh gave addresses on Citizenship. On January 11, an inspection trip was made to the steel car shops at Pullman and the new bridge shops of the American Bridge Co. at Gary, Ind. In the evening, a smoker was given at the society rooms, during which E. B. Frost of the Yerkes Observatory, gave a popular lecture on an astronomical subject.

WESTERN ASSOCIATION OF ELECTRICAL INSPECTORS

The annual meeting of the Western Association of Electrical Inspectors was held at the Plankinton House, Milwaukee, Wis., January 23–25, 1912. The sessions included the address of the president, V. H. Tousley, and the reports of committees; an address on The Protection of Buildings Against Lightning, by H. B. Long; a general discussion by the members regarding the improvements which have been made in the regulation of electrical hazards during the past year; addresses by W. J. Canada on Grounding of Conductors and Conduit, and by W. G. Middleton on Electrolysis; Reminiscences of a Pioneer Electrical Inspector, Franklin H. Wentworth.

PERSONALS

Claude M. Barron has entered the employ of R. W. Cameron & Co., New York. He was until recently associated with R. M. Wiggin of Mexico City, Mex.

C. E. Beck, formerly manager of the Sargent Steam Meter Co. of Chicago, Ill., has been appointed agent for the De La Vergne Machine Co. with offices in Chicago, Ill.

B. A. Behrend has been awarded the John Scott Medal by the Franklin Institute, for his contribution to the advancement of the electrical industry.

A. W. K. Billings has become associated with the Barcelona Traction, Light and Power Co., Barcelona, Spain.

A. C. Einstein, for a number of years president of the King Electric Light Co., the St. Louis County Gas Co. and the Suburban Electric Light and Power Co., has been appointed general manager of the Union Electric Light and Power Co. of St. Louis.

John W. Gray has been appointed superintendent of machinery of the Newport News Shipbuilding and Dry Dock Co., Newport News, Va. He was until recently associated with the Philadelphia, Pa. office of this company.

Walter J. Jones, consulting engineer of New York, has been appointed engineer to the Electrical Commission of the City of Montreal, Quebec. He will have immediate supervision over the work of gathering data and laying out a complete municipal underground conduit system for that city.

F. V. McMullin has been appointed treasurer of the Pennsylvania Forge Co., Philadelphia, Pa. He was formerly associated with the United Engineering and Foundry Co., Pittsburgh, Pa.

R. S. de Mitkiewicz has resigned as sales engineer with the Motor Engineering and Sales Co. of New York, to accept a position in the truck department of the Peerless Motor Car Co. of New York.

Wm. H. Parish has accepted a position as commercial engineer with the Westmoreland Coal Co., Philadelphia, Pa. Mr. Parish was formerly connected with the National Carbon Co., Cleveland O., as assistant superintendent.

B. G. Slaughter, Jr., has assumed the duties of engineer in charge of construction of the Pennsylvania Salt Manufacturing Co., Philadelphia, Pa. He was formerly connected with the Tennessee Copper Co., Copperhill, Tenn., in the capacity of chief engineer and superintendent of construction.

Chas. W. Stone has been appointed to succeed the late C. D. Haskins as manager of the lighting department of the General Electric Co., Schenectady, N. Y.

Frank R. Wheeler, formerly associated with the C. H. Wheeler Manufacturing Co., Chicago, Ill., has formed with R. B. Guernsey, the firm of Guernsey & Wheeler, with offices in San Francisco and Los Angeles, Cal., representing several eastern manufacturers of machinery.

Geo. R. Wood, consulting electrical engineer of Pittsburgh, Pa., has accepted a position in the electrical department of Berwin-White Coal Mining Co., Philadelphia, Pa.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for the Bulletin must be in hand before the 12th of the month. The list of men available is made up of members of the Society, and these are on file in the Society office, together with names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

0140 Engineer with broad experience, who has had some special training in handling office help and with a knowledge of accounting, to represent chief of department and make important decisions in his absence, in reorganization of the "internal economy" department of large Eastern city. Apply through Am. Soc. M. E.

0141 Man with considerable technical knowledge and organizing ability to take charge of municipal work having to do with contractors for street cleaning, garbage removal, paving, etc. Salary $6000. Eastern location. Apply through Am. Soc. M. E.

0142 Methodist Mission in Nadiad, India, wants mechanical engineer capable of giving instruction in both iron and wood work, to take charge of large industrial school.

0143 Ohio concern desires technical graduate, 25 to 30 years of age, preferably married, having practical experience as an executive in charge of an engineering department of a manufacturing plant, or as assistant to such executive, acquainted with modern systematic methods of conducting such work. Familiarity with construction of steel industrial and mining cars, design and construction of commercial auto trucks.

MEN AVAILABLE

350 Technical graduate, Junior member; qualified by five years' plant engineering experience, and proved ability to get results from men and equipment; to handle big work in either executive or shop end of manufacturing concern; thorough study of scientific shop management system and cost-accounting.

351 Technical graduate, Middle West state university, student member; desires position as assistant in mechanical laboratory instruction, in some Western or Middle West university; available about the middle of June 1912. Will consider work in gas-engine testing or erecting.

352 Member, graduate M. E.; 15 years' experience, wants position in teach-

ing or research work in connection with mechanical subjects; thoroughly versed in design of boilers, engines, turbines, mill and mining machinery and complete plants; some experience in structural steel and teaching; competent organizer and administrator.

353 Stevens graduate, married; varied experience with representative concerns in lines of manufacture and mechanical engineering, at present connected with large concern manufacturing product of high intrinsic value, requiring greatest detail, working in lines of reorganization and improvements of methods comprising planning, standardization of operations, classification, re-arrangement, cataloging, symbolizing stock, ready to take up work in similar lines. Leaving present employer with his full consent.

354 Professor of design; age 44; with 18 years' teaching experience, desires a change of location.

355 Member, technical graduate; 12 years' experience as a designer, construction engineer, mechanical engineer, and superintendent of industrial plants, desires a change of position; location, Middle West.

356 Member, graduate M. E.; 16 years' experience in steel works construction and other lines; charge both in field and office of the construction of several large plants; several years and until recently, chief engineer for firm of consulting engineers. Open for engagement along similar lines or any general lines.

357 Member of long standing; 40 years of age; married; 29 years' experience as machinist and tool maker; foreman, draftsman, designer, and superintendent to date, on modern manufacturing methods, planning work, writing up operations and designing tools and fixtures. Capable of taking hold of any reasonable mechanical proposition, tooling it up and estimating cost of machinery and tools, output, etc.

358 Associate member wishes to change; technical education; 12 years' experience, familiar with latest manufacturing methods; desires position requiring extensive knowledge of the shop, such as master mechanic or efficiency engineer.

359 Member in Baltimore is available as sales engineer and upon a commission basis, for Maryland, Virginia, West Virginia, and contiguous territory; experienced with machinery of cement mills, lime plants, quarrying, crushing, grinding, conveying, etc.

360 Technical engineer; age 31; 4 years' shop experience; 1 year electrical testing department; 7 years on design and construction of copper reduction works, locomotive shop and railway repair shop, desires position as designer or field engineer.

361 Engineer, technically trained with 14 years' shop experience, designing, engineering sales, etc., now employed as general manager, desires to change for position in business or executive end of manufacturing concern.

362 Associate member; 20 years' experience in designing all kinds of steam, pumping, blowing, hoisting, electric light and gas engines, gate hoists, transmission machinery, and power plants; desires a position as chief draftsman or chief engineer.

363 Mechanical engineer specialized in boiler practice and industrial furnaces. Extensive experience in design, construction and operation of power and manufacturing plants, desires position with consulting engineer or gas engineer for power or industrial plant.

364 Mechanical engineer, Junior member, technical graduate, wide experience in steam engineering including economical operation of leading types of water and fire tube boilers, operation of high-speed steam, hoisting engines, pumps, conveying machinery. Experienced in erection of locomotives for leading railway and good knowledge of steel mill work. Desires position where above experience will be of value, or as assistant to the engineer, manager or superintendent in some manufacturing business where there are good chances for advancement.

365 Sales manager or assistant; connected with selling end for the last five years; can handle any type or class of machinery, or open for manager of some manufacturing concern to handle plant.

366 Technical graduate, married, 32 years of age, desires position as manager or superintendent of small growing factory; practical experience in machine shop and drafting room, devising and installing complete cost, shop and production systems, factory executive in responsible charge. Experienced in laying out and installing industrial plants and electric installations.

367 Junior member, mechanical engineer with college training, one and one-half years' experience in machine shops, two as junior salesman, one as technical editor; familiar with safety appliances for shop and factory.

368 Member of long experience as chief engineer, superintendent, manager, and executive head of industrial corporations; confidential investigations and advice on industrial propositions and corporations; special experience in determining commercial value and "fiting risks" of patents, plants and manufacturing propositions with best method for marketing or development.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

AMERICAN MINING CONGRESS. Report of proceedings of 14th annual session, 1911. *Denver, 1911.*

AMERICAN RAILWAY ASSOCIATION. Proceedings, 1911. *New York, 1911.* Gift of the association.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS. Transactions, vols. 3–4. *Ames, 1910–1911.* Gift of the society.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Journal, vol. 33, nos. 7–12. *New York, 1911.*

AUTOGENES SCHWEISSEN, LÖTEN, NIETEN USW., E. de Syo. *Leipzig.*

BRITISH FIRE PREVENTION COMMITTEE. Journal, no. 8. Record of Special Commission to visit Paris, August 1911. *London, 1911.*

CHECK LIST OF BOOKS AND PAMPHLETS ON MUNICIPAL GOVERNMENT FOUND IN THE FREE PUBLIC LIBRARIES OF CHICAGO. *Chicago, 1911.* Gift of O. E. Norman.

COMPEND OF MECHANICAL REFRIGERATION AND ENGINEERING, J. E. Siebel. ed. 8. *Chicago, 1911.*

CONCRETE BRIDGES AND CULVERTS, H. G. Tyrrell. *Chicago-New York, 1909.*

DIRECTORY OF PORTLAND CEMENT MANUFACTURERS, 1911. *Chicago, 1911.*

EFFICIENCY TESTS OF MOTOR PULLEYS, Report of, made at Lowell Textile School, G. H. Perkins. Gift of Cork Insert Company.

EISERNE BRÜCKEN, Karl Bernhard. *Berlin, 1911.*

DIE ENTROPIETAFEL FÜR LUFT UND IHRE VERWENDUNG ZUR BERECHNUNG DER KOLBEN UND TURBO-KOMPRESSOREN, P. Ostertag. *Berlin, 1910.*

EXPERIMENTAL ENGINEERING AND MANUAL FOR TESTING FOR ENGINEERS AND FOR STUDENTS IN ENGINEERING LABORATORIES, R. C. Carpenter and H. Diederichs. ed. 7. *New York, Wiley & Sons, 1911.*

A new edition of this well-known laboratory manual, of which over 10,000 copies have been sold. It has been largely rewritten, containing over 200 pp. more than the sixth edition. It is of particular value to the consulting engineer as it contains in a single volume the principal standard methods of testing which have been adopted by various engineering societies, and an extensive series of tables useful in computing results.

EXPERIMENTS WITH OIL BURNING IN BOILER FURNACES. Louisiana Bull. no. 131. *Baton Rouge, 1911.* Gift of Louisiana State University.

FACTORIES AND WAREHOUSES OF CONCRETE. Philadelphia, Association of American Portland Cement Manufacturers. *1911.*

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PRATT & WHITNEY CO., *Hartford, Conn.* Vertical shaper, 7 pp.

RUSSELL & CO., *Massillon, Ohio.* Steam road locomotives, 33 pp.; gas tractors, 28 pp.; general utility traction engine, 32 pp.

VALLEY CITY MACHINE WORKS, *Grand Rapids, Mich.* Wood working machinery, 16 pp.

WESTINGHOUSE, CHURCH, KERR & CO., *New York.* Central power stations, 49 pp.

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UNITED ENGINEERING SOCIETY

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TRADE CATALOGUES

AMERICAN VANADIUM CO., *Pittsburgh, Pa.* Nine photographs of vanadium steel machine parts, 9 pp.

H. CHANNON CO., *Chicago, Ill.* Machinery and general supplies for railroads, manufacturing and power plants, 952 pp.

DU PONT DE NEMOURS POWDER CO., *Wilmington, Del.* Use of explosives on the farm, 118 pp.; dynamiting boulders and stumps, 28 pp.; tree planting with Du Pont dynamite, 24 pp.

FAY & EGAN CO., *Cincinnati, Ohio.* Woodworking machinery, 384 pp.

FORBES CO., *Philadelphia, Pa.* Water sterilization by heat, 80 pp.

MUNNING-LOEB CO., *Matawan, N. J.* Belt-driven and motor-driven electroplating dynamos, 19 pp.

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CHANGES IN MEMBERSHIP

CHANGES IN ADDRESS

ALBRIDGE, Frederick Royal (1911), Ch. Draftsman, Bessemer & Lake Erie R. R., and *for mail*, care of H. H. Lininger, 16 Plum St., Greenville, Pa.

ATKINS, Harold B. (1903), Cons. Engr. and Certified Pub. Acct., 1409 West St. Bldg., and *for mail*, 527 W. 121st St., New York, N. Y.

BARNES, Charles B. (1905; 1908), Asst. Wks. Engr., West. Elec. Co., Hawthorne Sta., Chicago, and *for mail*, 229 Wisconsin Ave., Oak Park, Ill.

BECK, Charles Edgar (Junior, 1911), Sales Mgr., De La Vergne Mch. Co., 1504 Fisher Bldg., and *for mail*, 4855 Winthrop Ave., Chicago, Ill.

BEECHER, J. F. (Associate, 1908), Checker Coke Oven Dept., Tenn. Coal, Iron & R. R. Co., and *for mail*, 2201 Fifth Ave., Birmingham, Ala.

BIRDSEY, Charles Robt. (Associate, 1907), Ch. Engr., U. S. Gypsum Co., 200 Monroe St., and *for mail*, 528 S. Millard Ave., Chicago, Ill.

BURCH, H. Kenyon (1910), Mech. Engr., 645 Bixel St., Los Angeles, Cal.

BURGOON, Charles Eli (1907), Burgoon-Matthews Elec. Co., 3 N. 20th St., Birmingham, Ala.

ESTABROOK, Mansfield (Junior, 1903), Niles-Bement-Pond Co., 111 Broadway, New York, N. Y.

GARDNER, Thomas M. (1903), Cons. Engr., Anna, Ill.

GRAY, John Wilson (Junior, 1895), Supt. of Mchy., Newport News Shipbuilding & Dry Dock Co., and *for mail*, 124 28th St., Newport News, Va.

HANZLIK, Henry J. (1903; 1910), Foreign Dept., Genl. Elec. Co., and *for mail*, 1 State St., Schenectady, N. Y.

HOLMAN, R. Claude (1907), Ch. Engr., Hooven-Owens-Rentschler Co., and *for mail*, P. O. Box 385, Hamilton, O.

HUTTON, Mancius S. (Junior, 1908), 257 W. 86th St., New York, N. Y.

JACOBS, Ward S. (1897; 1904), Treas., The Walton Co., and *for mail*, 530 Farmington Ave., Hartford, Conn.

KING, Roy Stevenson (1904; 1910), 612 Barnard St., Savannah, Ga.

KNAPP, Edwin C. (Junior, 1893), Mech. Engr., Am. Turbine Eng. Co., 17 Adams St., Brooklyn, and *for mail*, Westfield, N. Y.

LUEHRS, Daniel Michael (Junior, 1907), 282 Park View Ave., Detroit, Mich.

MAYSILLES, John Henry (1901; 1910) Genl. Foreman, W. C. Whitcomb Co., Rochelle, Ill.

NORDBERG, Carl Victor (1908), Rep., Nordberg Mfg. Co., Electric Bldg., Butte, Mont.

NOYES, Henry (1899), Life Member; Governing Dir., Noyes Bros., Ltd., 499-501 Bourke St., Melbourne, and Holmby Malvern, Melbourne, Australia.

PARSONS, George (1911), Am. Vulcanized Fibre Co., 500 Equitable Bldg., Wilmington, Del.

PROUT, Henry Byrd (Junior, 1911), Salesman, Westinghouse Mch. Co., 201 Devonshire St., Boston, and Hampton Court, Brookline, Mass.

SHELMIRE, W. H., Jr. (1899), 69th and Launton Ave., Oak Lane, Philadelphia, Pa.

SLAUGHTER, Benjamin Gabriel, Jr. (1911), Engr. in Charge of Constr., Pa. Salt Mfg. Co., Philadelphia, Pa.

PENRUDDOCKE, J. H. (1889), Mech. Engr., Farm 1464, Muhorini, British East Africa.

WOOD, Geo. R. (1906), Elec. Dept., Berwin-White Coal Min. Co., Arcade Bldg., Philadelphia, Pa.

YOUNG, E. R. (Junior, 1900), 1332 E. 111th St., Cleveland, O.

NEW MEMBERS

BALZER, Fritz (Junior, 1911), Mech. Engr. Charge of Drafting Dept., Troy Laundry Mchy. Co., Ltd., La Salle and 23d Sts., Chicago, Ill.

BARTLETT, George M. (1911), Mech. Engr., Diamond Chain & Mfg. Co., and *for mail*, 2609 N. Delaware St., Indianapolis, Ind.

BRYDON, Herbert Boyd (1911), Mech. Engr., H. M. Byllesby & Co., Chicago, Ill.

ELLISON, Lewis Martin (Associate, 1911), Steam Expt., Designer and Mfr., 6238 Princeton Ave., Chicago, Ill.

FREEMAN, Frederick Charles (Junior, 1911), Stacey Mfg. Co., Cincinnati, O.

GERDAU, Barthold (1911), Ch. Engr. and Managing Dir., Haniel & Lueg, and *for mail*, Peanderstr. 13, Düsseldorf, Germany.

HVID, Marinus (Junior, 1911), Designer, Blast Furnaces and Rolling Mill Equip., 7532 Champlain Ave., Chicago, Ill.

MOORE, James Leonard (1911), Ch. Engr., Kerr Turbine Co., Wellsville, N. Y.

NORTON, Homer Burdett (1911), Ch. Engr., Elk Tanning Co., and *for mail*, 302 Adams Ave., Ridgway, Pa.

RICE, Myron Wesley (Junior, 1911), Am. Ship Windlass Co., Cumberland St., Philadelphia, Pa.

ROWLEY, Frank B. (Junior, 1911), Instr. Engrg., Drawing and Descriptive Geometry, Univ. of Minn., and *for mail*, 414 Oak St., S. E., Minneapolis, Minn.

RUSSELL, Foster (Junior, 1911), Art Metal Constr. Co., and *for mail*, Y. M. C. A., Jamestown, N. Y.

SELSER, Thomas Watson (Junior, 1911), Ch. Draftsman Mech. Dept., San Pedro, Los Angeles and Salt Lake Ry. Co., and *for mail*, 324 Gertrude St., Los Angeles, Cal.

STRAUB, C. Lee (1911), 296 Fisk Ave., West Brighton, S. I., N. Y.

VOGT, Robert Friedrich (1911), Mech. Engr. Cons. Engrg. Dept., Allis-Chalmers Co., and *for mail*, 233 Queen Anne Pl., Milwaukee, Wis.

WALLACE, Erwin Van Doren (Junior, 1911), Teacher Mech. Drawing, Manual Training and Mathematics, Central High Sch., St. Louis, Mo.

PROMOTIONS

HARLAN, O. K. (1904; 1911), Mech. Draftsman, Box 65, Empire, Canal Zone, Panama, and 811 W. Oak St., Union City, Ind.

LEUTWILER, Oscar A. (1904; 1911), Asst. Prof. Mch. Design, Univ. of Ill., and *for mail*, 511 W. Green St., Urbana, Ill.

COMING MEETINGS

FEBRUARY–MARCH

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading, and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

AMERICAN ASSOCIATION OF RAILROAD SUPERINTENDENTS
March 17, annual meeting, Chicago, Ill. Secy., O. G. Fetter, Carew Bldg., Cincinnati, Ohio.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
February 9, monthly meeting, 29 W. 39th St., New York. Secy., F. L. Hutchinson.

AMERICAN RAILWAY ENGINEERING ASSOCIATION
March 19–21, annual convention, Chicago, Ill. Secy., E. H. Fritch, Monadnock Blk.

AMERICAN SOCIETY OF CIVIL ENGINEERS
February 7, 21, bi-monthly meetings, 220 W. 57th St., New York. Secy., C. W. Hunt.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Monthly meetings: St. Louis, February 7; New York, February 13; Boston, February 16. Secy., Calvin W. Rice, 29 W. 39th St., New York.

CANADIAN MINING INSTITUTE
March 6, annual meeting, Ottawa, Can. Secy., H. Mortimer-Lamb, Windsor Hotel, Montreal.

CEMENT PRODUCTS EXHIBIT
January 29–February 3, exhibit, New York. Office, 72 West Adams St., Chicago, Ill.

IOWA ENGINEERING SOCIETY
February 21–23, annual meeting, Davenport, Iowa. Secy., S. M. Woodward, Iowa City.

NATIONAL BRICK MANUFACTURERS ASSOCIATION
March 6–9, annual convention, Chicago, Ill. Secy., T. A. Randall, Indianapolis, Ind.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS
February 14–15, annual meeting, Boston, Mass. Secy., N. W. Gifford, 26 Central Sq., East Boston.

NEW ENGLAND RAILROAD CLUB

February 13, regular meeting, New American House, Hanover St., Boston, Mass. Paper: Mechanical Handling of Freight, W. C. Carr. Secy., G. H. Frazier, 10 Oliver St.

RAILWAY SIGNAL ASSOCIATION

March 18, semi-annual meeting, New York. Secy., C. C. Rosenberg, Bethlehem, Pa.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
February			
1	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
8	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
9	American Institute of Electrical Engineers	F. L. Hutchinson	8.15 p.m.
13	American Society of Mechanical Engineers	C. W. Rice	8.15 p.m.
16	New York Railroad Club	H. D. Vought	8.15 p.m.
28	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
March			
5	Institute of Operating Engineers	H. E. Collins	8.00 p.m.
8	American Institute of Electrical Engineers	F. L. Hutchinson	8.15 p.m.
12	American Society of Mechanical Engineers	C. W. Rice	8.15 p.m.
14	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
15	New York Railroad Club	H. D. Vought	8.15 p.m.
27	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
28	Institute of Operating Engineers	H. E. Collins	8.00 p.m.

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Yale University	Oct.11, 1910	L. P. Breckenridge	F. M. Jones	W. St. C. Childs
Rensselaer Poly. Inst.	Dec. 9, 1910	A. M. Greene, Jr.	W. D. Small	A. E. Moore
State Univ. of Ky.	Jan.10, 1911	F. P. Anderson	J. W. Cary	J. T. Lowe
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Turret Description

THE turret is a flat circular plate; it is mounted on a low carriage containing controlling mechanism. The connections of the turret to the carriage, and the carriage to the lathe bed, are the most direct and rigid, affording absolute control of the cutting tools. The turret is accurately surfaced to its seat on the carriage by scraping, and securely held down on that seat by an annular gib. In the same manner the carriage is fitted to the Vs of the bed; the gibs pass under the outside edge of the bed.

The index pin is located directly under the working tool and so close to it that there can be no lost motion between the tool and the locking pin. The turret is turned automatically to each position the instant the tool clears the work on its backward travel, and it is so arranged that by raising and lowering trip screws near the center of the turret, it may be turned to three, four or five of the six places without making any other stops.

A simple, accurate stop mechanism for the turret slide provides twelve independently adjustable stops, two for each of the six positions of the turret, or any other division required by the operator.

The *feeding mechanism* for the turret slide and the cross-feeding head receives its power through a speed-varying device which is under the convenient control of the hand wheel at head end of bed. One revolution of this wheel gives the full range of feeds, from drilling feed of 120-per-inch to coarse turning feed of 10-per-inch, and every intermediate feed.

A spring torc weighing device on the feed rod gives the pulling power of this feed mechanism a known value. This device yields at a certain predetermined pressure.

In operation the carriage is fed forward until it reaches one of the stops, against which it is held by this

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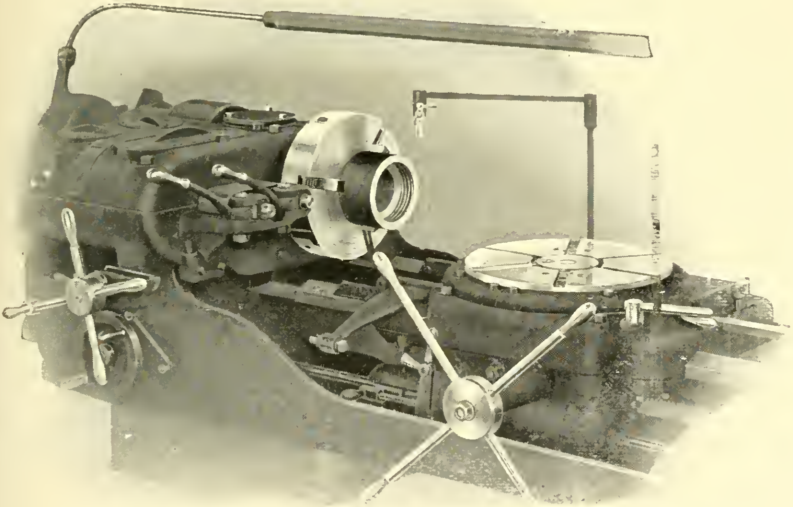
pressure till disengaged by the operator. Arresting the feed without releasing the carriage gives the tool a chance to accurately face the shoulder, leaving a smooth surface instead of the ragged face left when carriage is released under full cut.

It has been the practice heretofore to arrange the positive stop a thirty-second of an inch beyond the knock-off for the feed, and in the usual operation of a machine of this kind the feed knocks off, and then the turret slide, released, jumps back, and the tool digs in, cutting a slight groove just back of the shoulder. When on work requiring exact shoulder distances or smoothly-finished shoulders, the operator brings the slide against the positive stop, holding it there with as nearly as possible uniform pressure until the turner has surely faced its full length. In the present machine the turret is always fed against the positive stop and held there with a uniform pressure, insuring the most accurate results for shoulder length.



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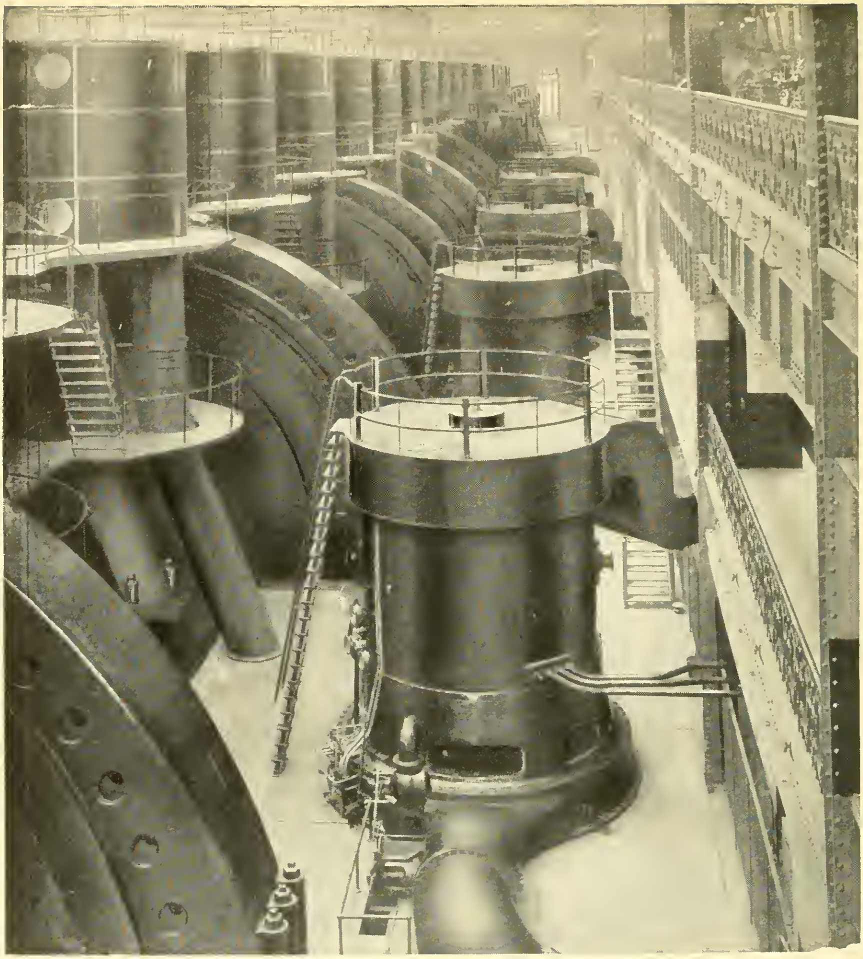

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Saved approximately 85 per cent of the condensed steam for return to the boilers.

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The above is abstracted from a paper read before the A. S. M. E. and A. I. E. E. by Mr. H. G. Stott, Supt. of Motive Power of the Interborough Rapid Transit Company, New York City, on his tests of the power plant which supplies the New York subway.

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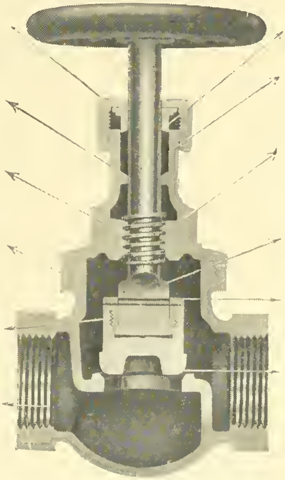


Stem has bearing at three points in the bonnet, steadying it centrally, causing the discs to remain at all times *central* with the seat.

Bonnet screwed on the outside of the body, fortifying the body against internal strain.

This regrinding disc can be replaced easily with the rubber disc or copper disc shown in valves at the bottom, all being renewable and interchangeable on the *same stem in the same valve*.

See the wide hexagons and the long threads.

Gland Packed.

Large Packing Box.

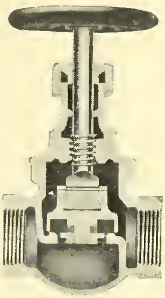
All threads engaged with bonnet when valve is closed, when you apply the most pressure and *need the most strength*.

Chamfered shoulder makes tight joint with recess in bonnet when valve is wide open, so you can repack valve when under pressure.

To regrind, a nail through this hole prevents the disc from revolving on the stem.

Regrinding disc radial where it makes contact with the seat, preventing cutting of both disc and seat. (Cut shows valve slightly open.)

For 175 pounds working pressure, each valve tested to 500 pounds.



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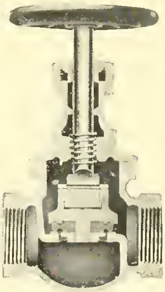

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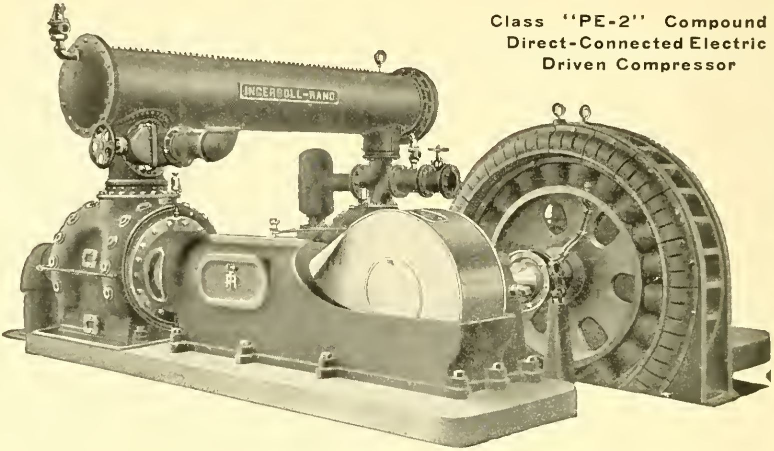

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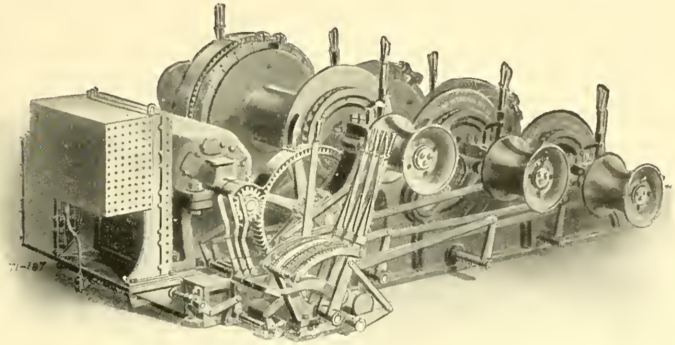

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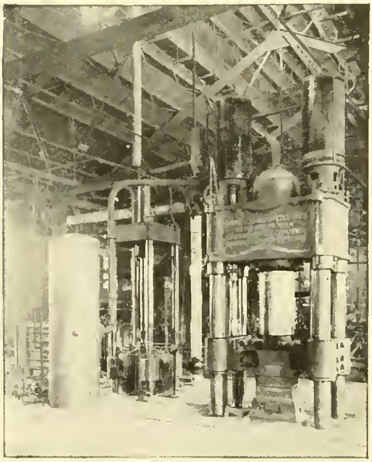

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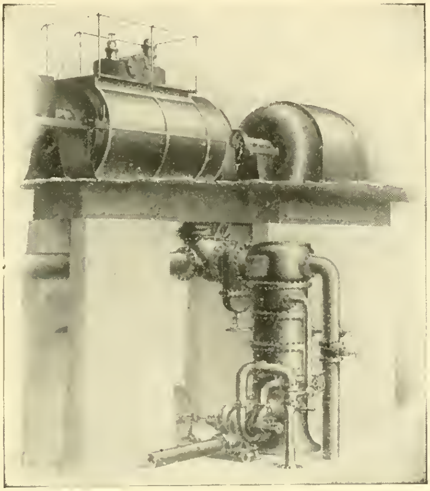

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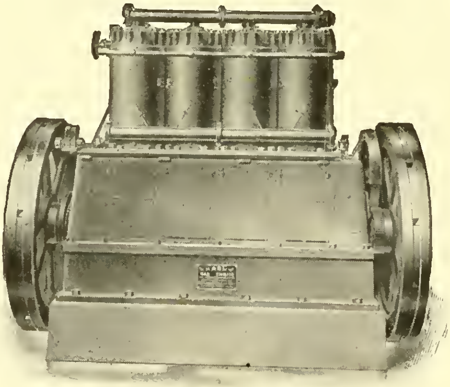

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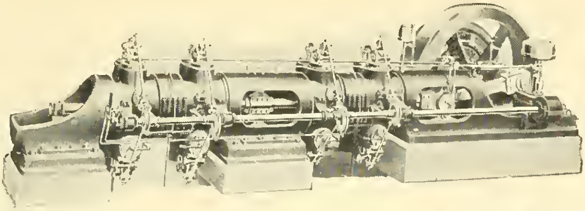

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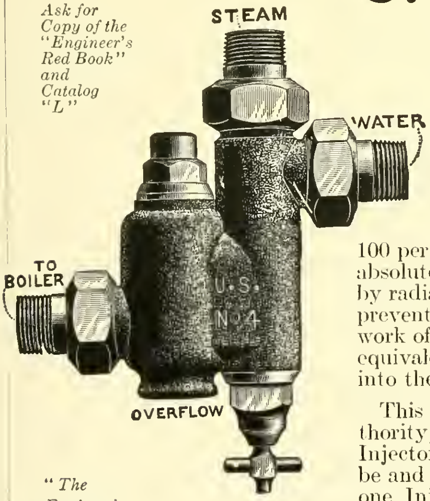

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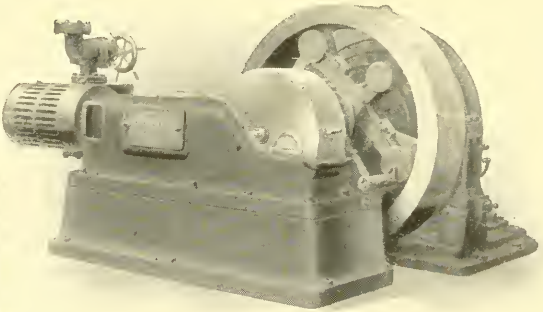

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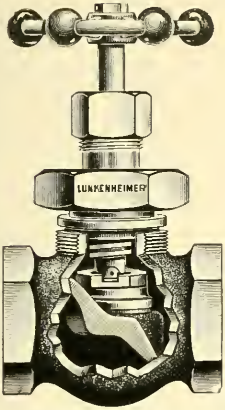

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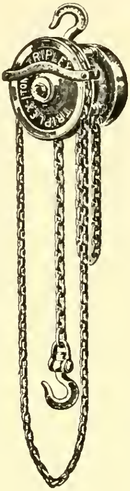

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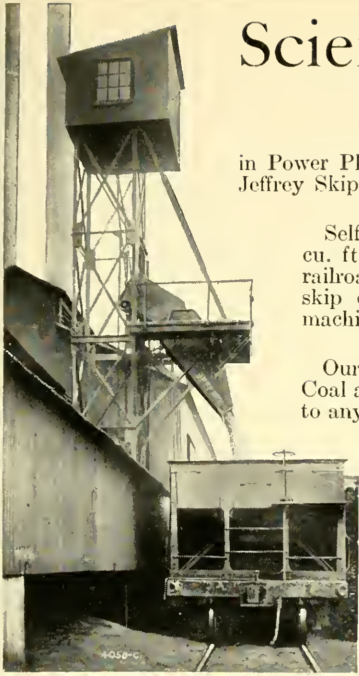

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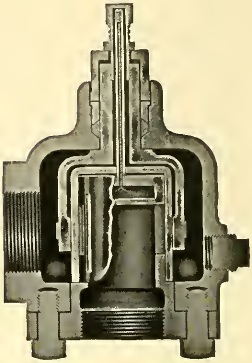

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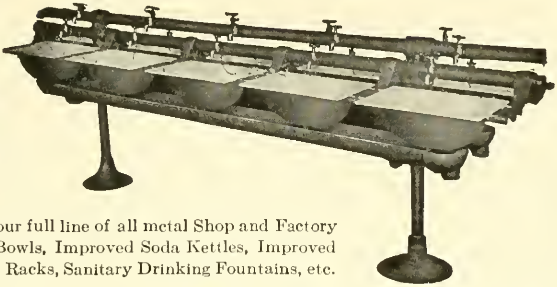

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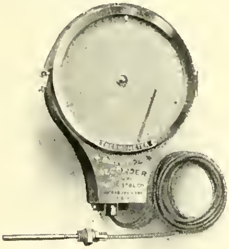

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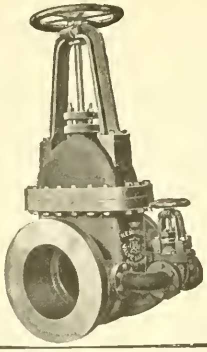

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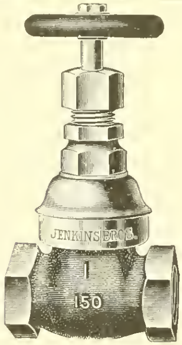

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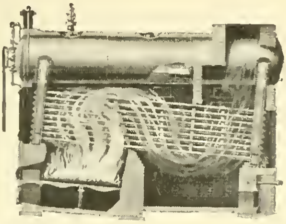

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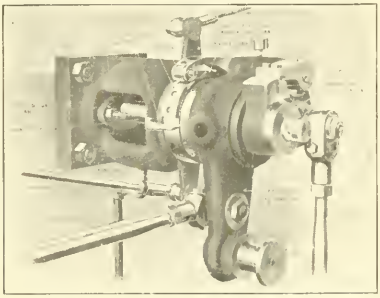

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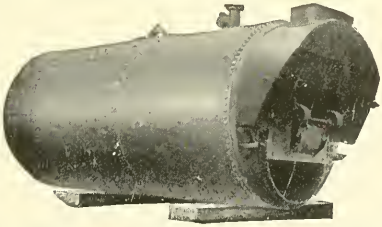

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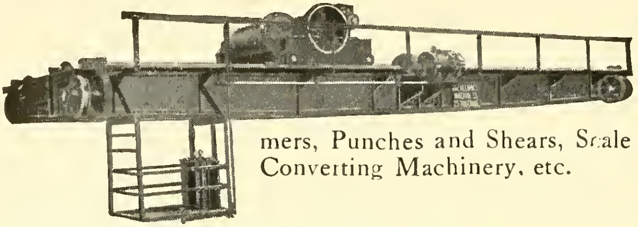

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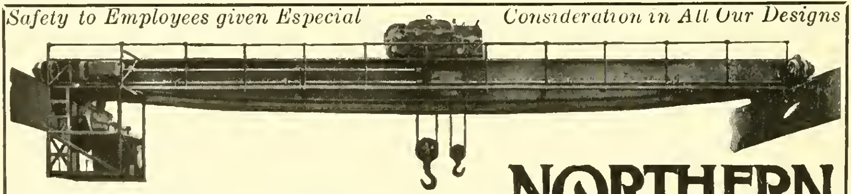

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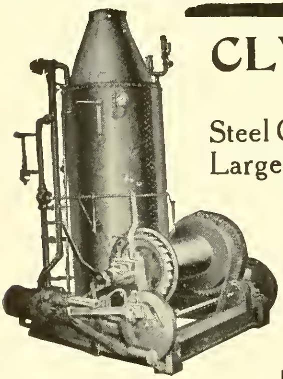

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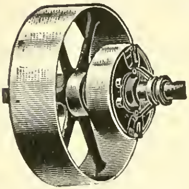

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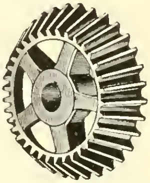

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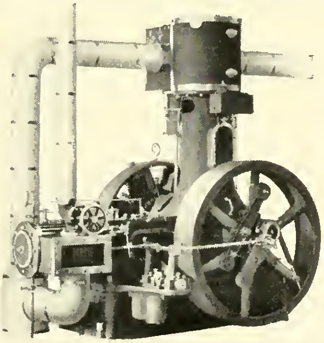

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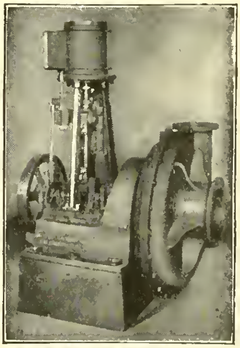

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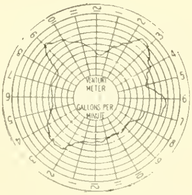

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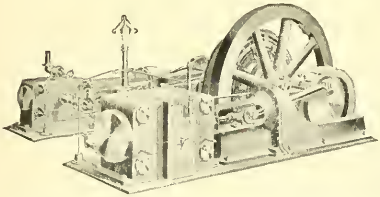

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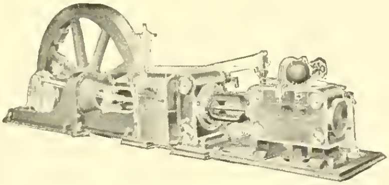

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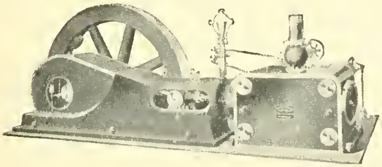

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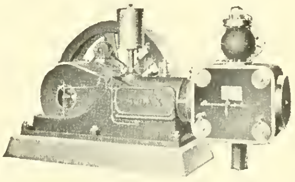

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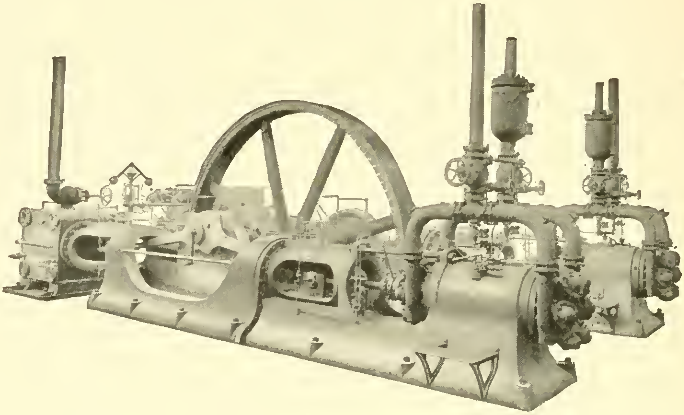

Duplex Ammonia Compressor driven by Cross Compound Corliss Engine

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Vilter Corliss Engines are equipped with an improved releasing gear giving high economy in steam consumption and reducing the wear on the reciprocating parts. They are of the horizontal type, built in all sizes from 25 H.P. up and furnished with either Girder, Heavy Duty or Rolling Mill Type Frames to suit individual load conditions and steam pressures. They are either Simple, Tandem or Cross Compound, condensing or non-condensing.

Excellent results are obtained where our Corliss Engines are used to drive our double-acting ammonia compressors. They are also admirably adapted for driving air compressors. For driving direct connected electric generators at higher rotative speeds the only change necessary is to equip them with our high speed, close-regulating governors.

All the refinements necessary to meet the exacting demands of modern steam engineering practice in a prime mover of this kind are incorporated in our designs. Steam and exhaust valves are double-parted and our cylinder castings are constructed with a single passage for the admission and exhaust at each valve. Cylinder clearance is reduced to a minimum. The steam and exhaust valve mechanisms are driven by either single or double eccentrics, the latter permitting a longer range of cut-off and greater overload capacity. Every part of our engine is designed with the idea of improving its mechanical efficiency and of giving the highest economy in every day operation.

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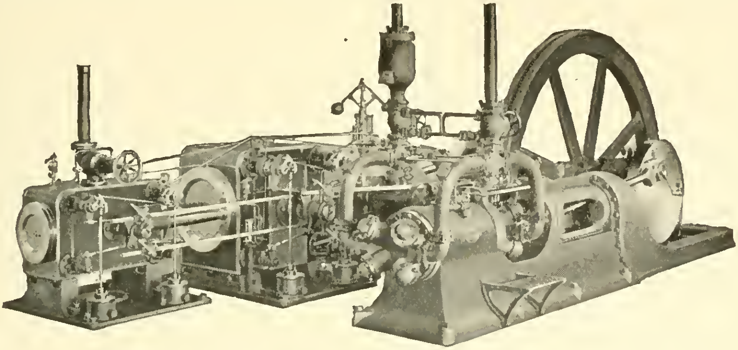


Ammonia Compressor driven by Tandem Compound Corliss Engine

AMMONIA COMPRESSORS

Our ammonia compressors of the horizontal double-acting type are built in consecutive cylinder sizes ranging from 6″ x 12″ to 24″ x 48″. Sizes 13″ x 26″ and larger are also built in duplex units of from 125 tons to 750 tons refrigerating capacity. All sizes are steam driven by our direct connected Corliss Engines. They are also adapted for driving by belt or rope transmission.

The design of our compressors is remarkably free from complication and the construction is such that long life, satisfactory service and freedom from trouble is assured. Careful attention is given to exactness of workmanship during the building of our compressors, and no detail of construction, however slight, passes inspection unless the workmanship is up to standard.

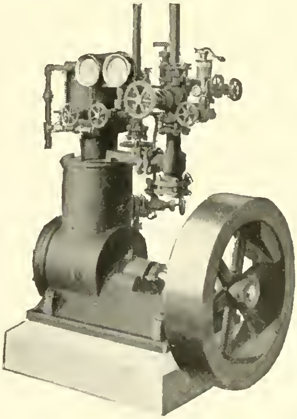
The cylinder and piston construction have special merit. The piston takes the form of an elongated sphere, presenting a large bearing surface to the cylinder walls. The cylinder heads are finished in comformity with this design and are turned to a true half sphere to conform to the shape of the piston, resulting in maximum strength and very small clearance spaces. This construction also gives the largest attainable valve area and permits the use of multiple suction and discharge valves in each cylinder head.

Every detail of our construction is fully described and illustrated in our bulletins, which we shall be glad to send to those interested.

SMALL BELT-DRIVEN SINGLE-ACTING COMPRESSORS

Our small vertical single-acting ammonia compressors are of the enclosed type, arranged for belt connection to an electric motor, gas or gasoline engine, line shaft, or small steam engine. They are designed with particular attention to the requirements of users of small ice-making and refrigerating plants. The fewest possible number of units and rigid construction insures perfect alignment and the least amount of wear on the moving parts. Particular attention has been given to the matter of automatic lubrication, accessibility for inspection and adjustment, and elimination of every troublesome element.

We are prepared to furnish this type of compressor in the following cylinder dimensions, viz: 4″ x 6″, 5″ x 6″, 6″ x 8″, 7″ x 8″, 8″ x 9″ and 9″ x 9″ and to furnish full information relative to each size. These compressors are rated at from one to fifteen tons refrigerating capacity and are also furnished in duplex units with a single belt wheel.



Vertical Enclosed Type Single-Acting Ammonia Compressor for Belt Drive

RATHBUN-JONES ENGINEERING COMPANY

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RATHBUN GAS ENGINES

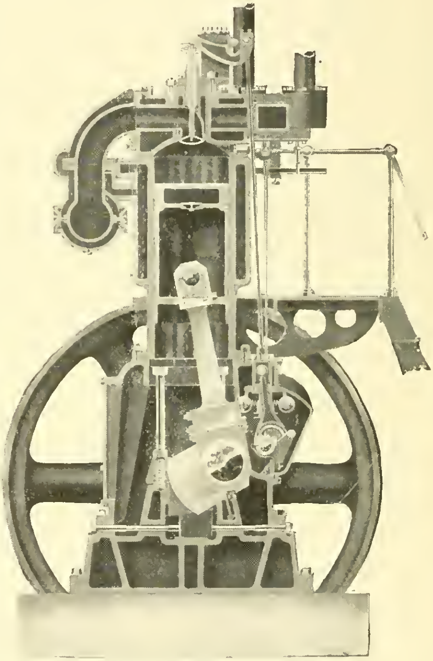
CONSTRUCTION DETAILS

Cylinder and Head Construction:—Valves are placed directly in the head, so that the surface of combustion chamber exposed to the burning gases is reduced to a minimum. The heads are readily removed, and both cylinders and heads are provided with large openings through which all parts of both castings can readily be reached for inspection and cleaning.

Piston Construction:—The piston is built with an air pocket in the head which prevents the accumulation of oil on the hot center of the casting.

Five rings are provided, the top one being an ordinary snap ring, the others of special construction such that they always maintain contact against the lower face of the slot instead of working from side to side with the motion of the piston. These prevent the oil from passing into the combustion chamber.

A very valuable feature is the connection through the cylinder wall to the space between the two lower rings, which carries off the burned gases, dirty oil, and products of wear from the cylinder instead of allowing them to work down into the engine housing.



Section showing details of construction

Main Journal Construction:—The Main Journal Boxes are held firmly between jaws which form part of the engine base, giving a very rigid construction, and rest on wedges adjustable from the outside of the engine.

The Journal Cap Studs are continued upward through the housing, forming staybolts, through which all stresses incident to the pressures in the cylinders are carried directly to the main journals, the cast-iron housing not being relied upon to transmit these stresses.

The housing, however, is very heavily ribbed, and in connection with the stay bolts gives an extremely strong construction.

Connecting Rod:—The connecting rod is of forged steel with strap ends, adjustment at both crank and cross head being obtained by wedge and bolt. Boxes at crosshead end are of phosphor bronze working on a hardened and ground steel pin. The malleable iron boxes at crank end are tinned and then lined with genuine babbit.

Housing Construction:—The housing has unusually large doors, thus providing for most convenient access to the rods, journals and operating mechanism.

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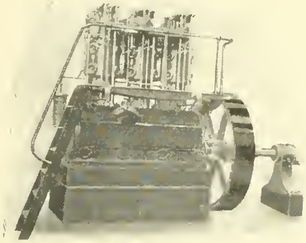
Governor:—The Governor is of the Fly-Ball type, operating directly on the throttle valve. The Governor also changes the timing of the ignition to suit the compression as affected by the throttling. This is an important feature affecting the economy when operating on variable loads. The governing is effected by the action of a two-disc balanced valve operating directly on the mixture. This type of valve is particularly free from the effects due to dirty gas. The quality of the mixture is regulated by an additional valve in the gas line, and by a device peculiar to this engine, two settings of the mixture may be made, one for light load and another for full load. This arrangement assures an automatic maintenance of a proper mixture at practically all loads.



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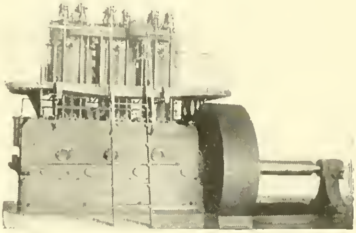

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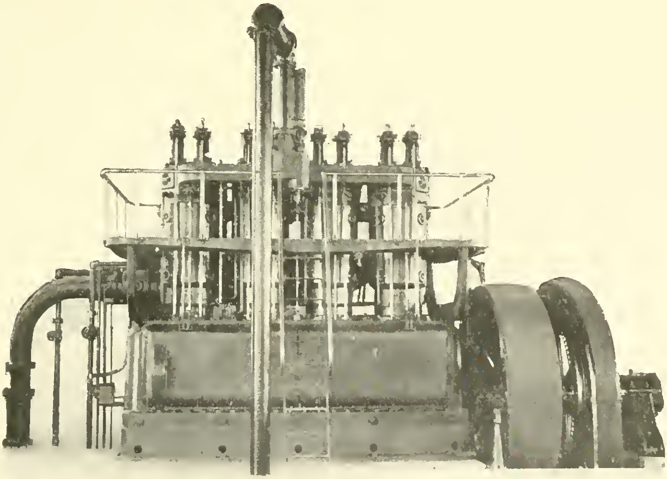

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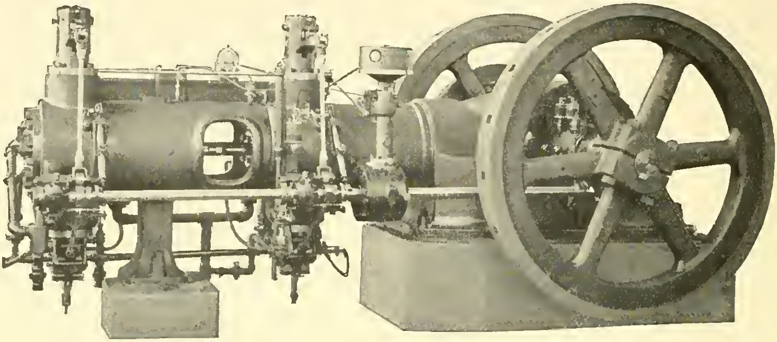

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Uses Producer, Natural and City Gas, Gasoline and Distillate.

Only change necessary in change of fuel is length of connecting rod for altering compression and exchange of fuel handling devices.

Economy ranges from 10,000 to 12,000 BTU, depending on size.

All sizes with water-cooled exhaust valves; all but No. 2 have water-cooled pistons and piston rod. No water joints subject to explosion pressures.

Governs by varying lift of inlet valves. Good regulation.

Pulley or flexible coupling bolted to flywheel, either side.

Ignition make-and-break or jump spark, both for continuous service.

Our "Show-me" guarantee means much to the buyer. Get it.

Crank Shaft half of cylinder bores. Main bearings removable bushings.

Automatic Air Starting Equipment always included.

Gas Producers and Dynamos furnished. Quick delivery a feature.

Engineers can safely use for estimate figures $80 per H. P. in smallest to $60 per H.P. in largest sizes. This includes engine and anthracite producer, delivered and fully installed above foundations.

We deal with purchasers or Engineers only. We have no Agents.

APPROXIMATE RATINGS AND FLOOR SPACE

Fuel	Compression	Engine No. 2		Engine No. 3		We twin the No. 4 and No. 5			
						Engine No. 4		Engine No. 5	
						When twinned, double rating, same speeds.			
		H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.
Natural Gas.....	140 lbs.	40 30	325 250	60 45	290 220	75 60	275 225	110 85	260 200
City Gas........	125 lbs.	40 30	325 250	60 45	290 220	75 60	275 225	110 85	260 200
Gasoline or Distillate........	75 lbs. to 100 lbs.	35 30	325 275	55 45	290 240	70 60	275 235	100 85	260 220
Gasoline or Distillate with Water	100 lbs. to 125 lbs.	40	325	65	290	80	275	120	260
Producer Gas....	160 lbs. to 180 lbs.	30 25	325 275	45	290	55	275	85	260
Over all space		5′-0″x10′-0″		11′-6″x5′-7″		12′-6″x6′-0″ Twinned 12′-6″x11′-6″		14′-0″x6′-10″ Twinned 14′-0″x13′-6″	

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COAL AND WATER GAS APPARATUS EXHAUSTERS, CONDENSERS, SCRUBBERS,
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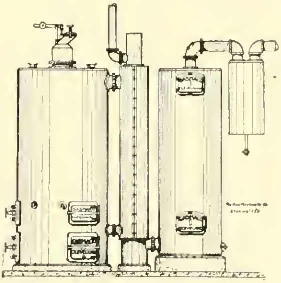

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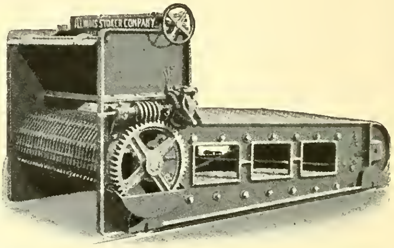
THE ILLINOIS STOKER COMPANY'S GRATE STOKER



Showing driving mechanism of Stoker

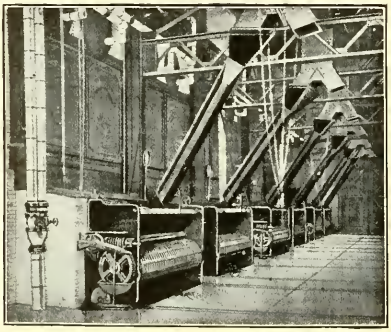
The general view of this Stoker is given in the illustration herewith. The coal is supplied to the traveling grate from the hopper, shown in the upper front part of the furnace. The grate in carrying the coal into the furnace passes under an adjustable gate which can be raised to give any desired thickness of fuel bed up to twelve inches by turning the hand wheel at the top of the Stoker. The adjustment, together with the variable speed at which it is possible to operate the grate by means of the speed adjusting lever shown on the driving mechanism, makes it possible to feed any desired number of pounds of coal per square feet of grate surface per hour into the furnace.

By controlling the thickness of the fuel bed and speed with which the coal is fed into the furnace, it is possible to obtain any desired load from the boiler with coal of either very high or very low heat value, or coal very small or coarse in size.

By raising or lowering the gate and determining the thickness of the fuel bed, which is fed into the furnace, proper allowance can be made for the burning of coal of various sizes. For example: Assuming that the draft over the fire is constant, the larger size of coal will have larger air spaces between the individual pieces of coal than a coal of smaller size, so that with a given draft more air will be forced through a coal bed six inches thick while burning the larger size of coal than will be forced through the same thickness while using coal of a smaller size. Adjustment should therefore be made in each case so as to obtain the proper amount of air through the coal for the proper burning of the particular kind of coal used.

The ease with which the gate can be lowered or raised in the Illinois Stoker makes it feasible to maintain the proper thickness of the fuel bed for each kind of coal supplied to the furnace. The exact thickness of the fuel bed is at all times indicated in inches by the gauge shown just above the handle for raising the gate.

Attention is called to the solid construction of the side frame of this Stoker, which is cast in one single piece from the front to the rear of the Stoker, so that the entire chain and driving mechanism is supported on this single solid casting. This construction is found only in the Illinois Stoker and makes it the most rigid and substantial Stoker on the market. Note the heavy ribs on all edges of the side frame.



Illinois Stokers in operation

GOOD FEATURES OF ILLINOIS STOKER

Heavy Castings throughout and Rigid Bracing. Sprockets engage on Rollers, not on rods. Evenness of chain due to close spacing of rollers. Uniform distribution of air supply through coal. Patented air baffling system in rear of grate. Large combustion space due to inclined grate. Excellent speed controls. Short Link. Minimum loss of coal through grate. Independent flat ignition arch. General appearance and mechanical design. No rear sprockets to cause trouble.

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TYPE "K" WATER SOFTENER

HOW TO GET SOFT WATER

The Kennicott Method of Softening Water consists of AUTOMATICALLY treating VARYING QUANTITIES OF WATER with proportionately VARYING QUANTITIES OF MATERIALS in an automatic apparatus which purifies and softens the water AT THE LOWEST POSSIBLE COST.

The Kennicott Water Softener, as this apparatus is called, is CONTINUOUS IN ITS ACTION, automatically starting and stopping with the beginning and ceasing of the flow of water into the machine. The water is pumped but once into the Softener, and it is delivered at the top. The water as it flows into the Softener furnishes all the power the apparatus requires, both for mixing the chemical re-agents with the water to be purified, as well as for operating AUTOMATICALLY all the mechanism of the apparatus.

After the impurities in the water to be treated have been precipitated from the water by the chemical reagents, they are AUTOMATICALLY removed from the water as it passes through the apparatus, and the purified water overflows BY GRAVITY from the top of Softener into the storage tank, WITHOUT THE NECESSITY OF REPUMPING.

The machine starts and stops automatically, according to the supply of hard water. The amount of water TAKEN IN is regulated entirely, up to the maximum capacity, by the amount of water DRAWN OUT.

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We lay particular stress upon this point because a CORRECT analysis is the all-important first factor in the solution of any hard water problem, and because we have spent a small fortune perfecting our laboratory work. The skill, care and thoroughness exercised in our water analysis are but seldom considered necessary in commercial laboratories.

We publish a full description of the operation of our TYPE "K" SOFTENER which gives detailed information and many references from large concerns who are using this system. This covers almost every line of business, and the matter referred to will be mailed you upon request.

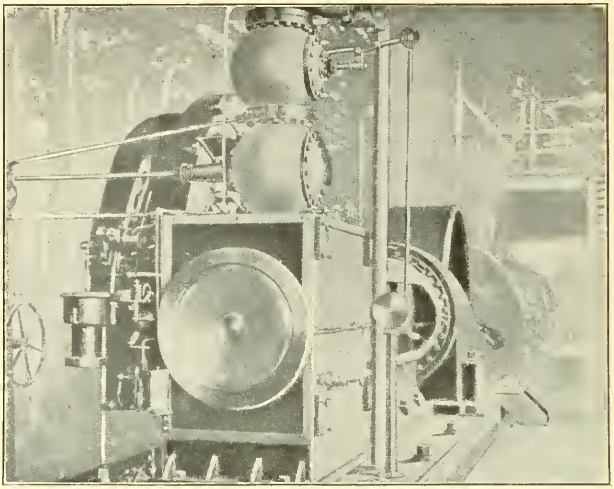
Our machines are guaranteed to produce uniform results—and we make good.

THE
STRONG, CARLISLE & HAMMOND CO.

CLEVELAND, OHIO

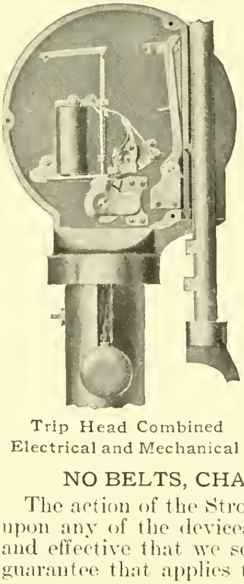
STRONG ENGINE STOP, STRONG STEAM TRAP, STRONG SEPARATORS FOR OIL OR STEAM, STRONG VACUUM TRAPS, STRONG REDUCING VALVES, STRONG PUMP GOVERNOR AND PRESSURE REGULATOR.

THE STRONG ENGINE STOP



One of ten engines in large mill equipped with this apparatus

The Strong Engine Stop is composed of three main parts, the quick-closing valve, the trip head, and the speed limit. The stop may be operated electrically or mechanically or by combining the two methods.



Trip Head Combined Electrical and Mechanical

Whether electrically or mechanically operated the result is the same: over-speeding of the engine is impossible. The "Speed Limit" device at the first instant of "Running Away," as evidenced by the increased speed of the line shaft, throws out a trip, which lets fall a rod and operates the "Quick Closing Valve." As soon as the trip is released, an alarm bell starts ringing and continues to ring until the trip head is reset. The engine having been brought to a stop by the closing of the quick acting valve, cannot be started until the stop has been reset.

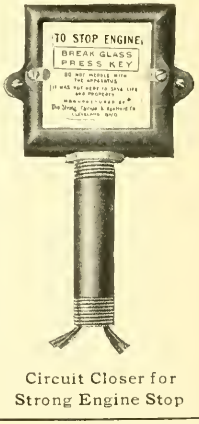
CIRCUIT CLOSERS

At any desired points in the Engine room or about the mill, circuit closers may be installed as shown in the accompanying illustrations, the action of which in stopping the engine is practically instantaneous.

NO BELTS, CHAINS, GOVERNORS, ETC.

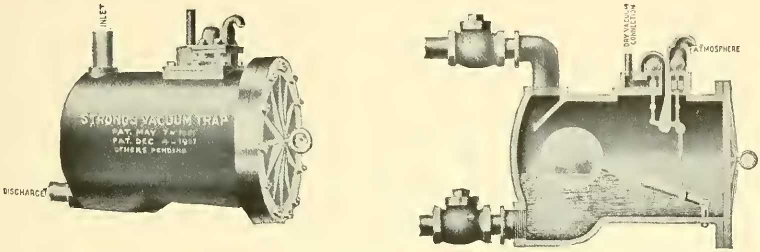
The action of the Strong Engine Stop is not dependent upon any of the devices named above, but is so simple and effective that we sell and install it under the same guarantee that applies to all "Strong" Specialties.

"*We don't want a cent of money until you are satisfied.*"



Circuit Closer for Strong Engine Stop

THE
STRONG, CARLISLE & HAMMOND CO.



Strong Vacuum Trap

The Strong Vacuum Trap automatically removes water from the vacuum lines of condensing engines, from the receivers of compound engines, from vacuum oil separators, etc., thus preventing accidents which might otherwise occur from the back suction of water into engine cylinders.

The Strong Vacuum Trap is also designed for returning condensation from coils, radiators, etc. of low pressure heating systems, direct to the boiler.

CONSTRUCTION.—The Trap consists of a cylindrical shaped body made from a high grade of cast iron, to which is bolted the head. This joint is machined and absolutely tight. To the top of the trap is attached the frame for the valves with a dry vacuum and atmosphere ports as shown by cut. Into this frame are screwed the seats for the vacuum and atmospheric valves. The valves consist of ground brass balls, operated by levers having heavy phosphor bronze bearings. The mechanism is operated by a Hercules patented copper float connected by heavy phosphor bronze and brass rods. No steel or iron is used in the working parts. The traps have no trunnions to adjust, no stuffing boxes to pack, no tilting devices to balance, and REQUIRE NO STEAM TO OPERATE THEM when discharging the water to the atmosphere and only a sufficient amount of steam to balance the back pressure when discharging to an elevation.

There is not a delicate part in their construction. The valves are in the top of the trap and may be inspected by removing the small caps encasing them. It is impossible for dirt to get at the working parts, as they are above the water line and almost the length of the trap away from the inlet. Every trap is inspected and rechecked before leaving our factory, and is ready to go into service.

TABLE OF SIZES AND CAPACITIES

Size No.	Outlet and Inlet	Distance Floor to Inlet	Total Length	Total Height	Diameter Body	Diameter Flange	Capacity Gallons Hour—Over	Shipping Weight	List Price
	Inches	Inches (Center of Inlet)	Inches	Inches	Inches	Inches			
8	1½	16	24	23	11	14	400	235	$120 00
9	2	21½	28	29	18	20½	700	410	200.00
10	2½	21½	28	29	18	20½	1000	410	200.00
11	3	21½	28	29	18	20½	1600	410	200.00

Swing check valves are furnished for inlet and outlet. Ball and lift checks should not be used

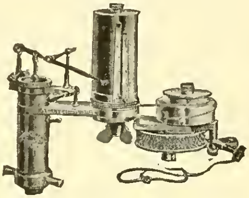
Discount on application

RICHARD THOMPSON & COMPANY

126 LIBERTY ST., NEW YORK, N. Y.

THOMPSON TWENTIETH CENTURY STEAM ENGINE INDICATOR REDUCING WHEELS, PLANIMETERS, ETC. THE THOMPSON DAMPER AND PRESSURE REGULATOR; SHAKING, DUMPING AND STATIONARY GRATE BARS; SOOT EJECTORS, 20TH CENTURY TUBE CLEANERS, ETC.

THOMPSON'S 20TH CENTURY STEAM ENGINE INDICATOR



Design.—Great care has been taken to have each part properly proportioned or the duty to be performed, giving strength and weight where required, and having working parts of such light weight that a quick and accurate response to the steam pressure is always insured.

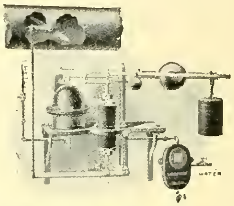
The best material and workmanship obtainable is used, and it is unsurpassed in finish and appearance.

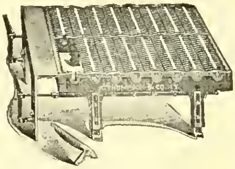
THE THOMPSON DAMPER AND PRESSURE REGULATOR

The Thompson Automatic Damper Regulator has ample power (from water pressure) to move a damper or dampers in either direction by water pressure and is not of necessity wide open or shut.

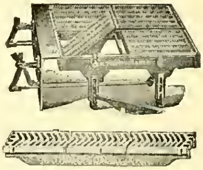
It will open or close dampers on a variation of one pound of steam, or will make a partial stroke in either direction and stand at any intermediate point between the open and closed positions.

Every regulator is tested and guaranteed to work as above stated.





For
All Kinds
of Fuel
and
Styles
of
Furnaces



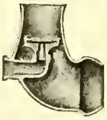
THOMPSON'S SHAKING, DUMPING AND STATIONARY GRATE BARS

Other Grate Bars manufactured and sold by this company to meet varied conditions of service and fuel are:

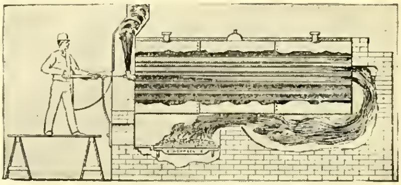
- The Twentieth Century Shaking and Dumping Grates
- The Steel Shaking and Dumping Grates
- Thompson's Stationary Grates
- Interlocking, Tupper and Adams Style Grates
- Single, Double and Cluster Grates
- Sectional Round Grates

The Soot Ejector Complete

Enlarged View of Central Tip



Sectional View of Head



Soot Ejector in Operation

THOMPSON'S PATENT SOOT EJECTOR

Thompson's Soot Ejector does the work quickly and thoroughly. No steam is admitted to the tubes, and no soot blown around the boiler room, or into the tubes already cleaned.

When in the market for any of the above kindly write us.

THE FOSKETT & BISHOP CO.

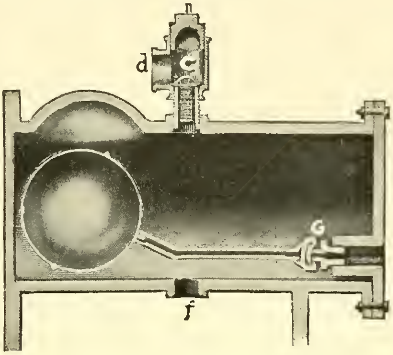
NEW HAVEN, CONN.

ENGINEERS AND CONTRACTORS, POWER PLANTS, GRINNEL AUTOMATIC SPRINKLERS AND APPLIANCES, HEATING, PLUMBING AND GAS FITTING, STEAM TRAPS, STEAM SPECIALTIES

THE FOSKETT & BISHOP PATENT IMPROVED STEAM TRAPS

DESCRIPTION.—The valve comprises the seat which screws into the head, and a disk which is attached to the seat by a hinge and has composition packing set in a slot made in said disk.

G is a heavy copper ball or float tested at a pressure of 300 pounds per square inch, attached by a brass rod to the disk of said valve. The outlet in head is where the water is discharged from the trap; D is the steam and water inlet; C is a copper strainer or basket; H is a plug, by unscrewing which access is had to the strainer for cleaning it; F is an outlet for drawing off all the water from the trap if desired, or discharging water of condensation when exhaust steam is used.



Patent Improved Steam Trap

OPERATION.—When steam is let on to radiators or coils to which the trap is attached, the water flows before the steam into the shell until the float G is raised, which lifts the disk from the seat of the valve and the water is discharged through outlet in head. When enough water is thus discharged to allow float G to fall, the valve is closed and the water again accumulates preparatory to another discharge; so it continues to work, never failing to discharge the water if enough is present to raise the float.

STANDARD SERVICE.—These Traps are recommended for any service requiring the removal of water of condensation without escape of the steam behind it.

For draining the condensation from steam pipes, coils, and apparatus employed in steam heating, steam kettles, vacuum pans, mash kettles, steam engine supply pipes and separators, evaporating pans, steam jackets on engines and pumps, ice machine stills, etc.

PRESSURE CONDITIONS.—In ordering it is important that the steam pressure under which they are to be used should be stated.

The Standard Trap is designed for an extreme pressure of 100 pounds, but where this pressure is to be constant, or likely at any time to exceed this limit, it is better to use the extra heavy type.

Where the Trap is to be used under extreme low pressure conditions,—1 to 20 lbs.,—the duty should be specifically stated, in order that a valve of proper area may be supplied. For this duty the Standard Trap is furnished, but with a larger opening than is used for the ordinary service, which is between 20 and 100 lbs.

TRAP CONNECTIONS.—In selecting a Steam Trap for a given duty it should be borne in mind that the size of the inlet in no way governs the capacity of the Trap, therefore the pipe entering Trap at "inlet" may be arranged to suit connections without affecting the operation of the Trap—care being taken that a Trap of proper capacity is selected for the work.

Should the duty exceed the capacity of the largest Trap listed, two or more Traps may be readily placed side by side, connected to a common horizontal header and operated as one Trap, in order to obtain the necessary trappage capacity.

SIZES, DIMENSIONS, CAPACITIES

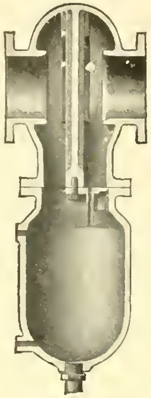
Number of Trap	0	1	2	3
Size of inlet connection	1 in.	1¼ in.	1¼ in.	2 in.
Size of outlet connection	½ "	½ "	¾ "	1¼ "
Maximum discharge lbs. water per minute	2	4	8	20
Greatest number of lineal feet of 1 inch pipe surface to which trap should be applied	800	1500	4000	10000

HARRISON SAFETY BOILER WORKS

3199 N. 17TH ST., PHILADELPHIA, PA.

COCHRANE FEED WATER HEATERS, COCHRANE STEAM AND OIL SEPARATORS, SORGE-COCHRANE HOT PROCESS SYSTEM OF WATER SOFTENING.

COCHRANE STEAM SEPARATORS protect engines, turbines or pumps from damage by water brought over from the boiler by priming, or condensed in pockets in the steam line. They also remove the small percentage of water or moisture always present in steam, thereby permitting the saving of from 25 to 50% of the cylinder oil, while obtaining better lubrication with less friction and wear. The removal of the water from steam used by turbines results in improved economy, and reduces blade erosion. Full particulars, sizes and dimensions are given in our "*Separator Catalog.*"

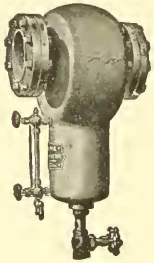


Showing general construction of horizontal form of Cochrane Separator

COCHRANE RECEIVER SEPARATORS are distinguished by extra large wells or receivers, which not only provide storage for large volumes of water until drained away by the trap, but also act as reservoirs for steam, which, being placed close to the engine throttle, equalize pulsations in the steam line and maintain a higher average pressure in the steam chest, while permitting the use of smaller piping and fittings, which are less expensive in first cost, maintenance and loss of heat by radiation. Write for Engineering Leaflet No. 10 on "*Recent Developments Affecting the Use of Separators in Connection with Live and Exhaust Steam Piping.*"

Cochrane Horizontal Receiver Separator

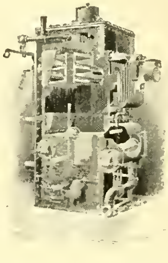
COCHRANE OIL SEPARATORS installed in exhaust lines from steam engines thoroughly purify the exhaust steam of grease or cylinder oil, so that the steam can be used safely and satisfactorily for heating water by actual contact, or in heating or drying coils, exhaust turbines, absorption ice machines and other apparatus, and so that the condensate from such apparatus may be returned and fed to the boiler, or utilized for industrial purposes. Over 10,000,000 H.P. of boilers are protected against oil by Cochrane Separators. Ask for a copy of our "*Separator Talks.*"



Cochrane Horizontal Oil Separator

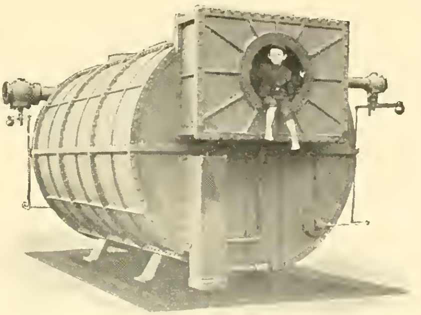
COCHRANE RECEIVER OIL SEPARATORS are used in connection with mixed flow or exhaust turbines, not only to remove the water and oil from the steam before it enters the turbine, but also serving as muffle tanks or expansion chambers, wherein the intermittent flow of steam from the engine to the turbine is equalized. We shall be glad to submit suggestions regarding any particular case upon receipt of information.

THE COCHRANE OPEN FEED WATER HEATER serves as a receptacle in which the boiler feed is heated to the full temperature possible by means of exhaust steam. Spraying the water through the steam bath of the heater drives off air and gases (rendering the water non-corrosive) and scale-forming carbonates. The Cochrane Heater also performs the functions of an automatic make-up water regulator, feed-water skimming tank and filter, oil separator and expansion or muffle tank. Cochrane Heaters are made in all sizes, up to 20,000 H.P. Our catalog of "*Cochrane Heaters and Their Use in Condensing and Non-Condensing Steam Power Plants*" is at your command.



Interior view of Cochrane Open Feedwater Heater

HARRISON SAFETY BOILER WORKS

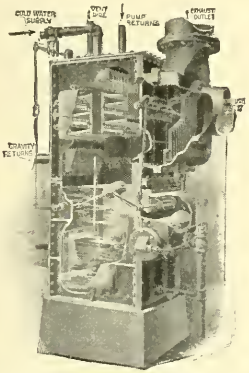


Cochrane Horizontal Cylindrical Heater and Purifier

COCHRANE HORIZONTAL CYLINDRICAL HEATERS are especially adapted for situations where headroom is limited, or where it is desired to provide for the storage of very large volumes of hot water.

COCHRANE HEATERS EQUIPPED WITH EXTRA LARGE STORAGE CAPACITY are supplied to paper mills, tanneries, textile mills, and other plants wherein the storage of hot water is required.

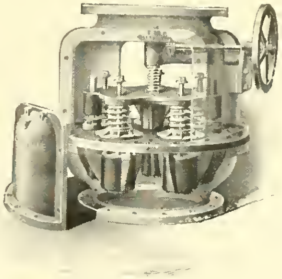
COCHRANE STEAM-STACK AND CUT-OUT VALVE HEATERS AND RECEIVERS save from $50 to $500 on the first cost of equipping plants where the surplus exhaust steam not required in heating the boiler feed water is utilized in exhaust steam heating systems or in low-pressure turbines or absorption ice machines. The extra large separator attached to the heater is of sufficient capacity to purify of oil all steam exhausted by engines, pumps, etc., thus saving the cost of an independent separator with trap, in a bypass around the heater. The application of this heater in connection with the leading commercial exhaust steam heating systems is explained in our "*Exhaust Steam Heating Encyclopedia*," sent upon request.



Cochrane Steam-Stack and Cut-Out Valve Heater and Receiver

The formation of hard scale, and corrosion within the boilers, are prevented by the SORGE-COCHRANE HOT PROCESS WATER SOFTENING SYSTEM, which also performs all the functions of the Cochrane Open Feed Water Heater. No lime is required, the feeding of the one reagent is therefore simple and automatic, and the apparatus can be looked after by ordinary boiler room labor. Ask for pamphlet "*What Scale Does to Boilers*" and "*Hot Process System Catalog.*"

THE COCHRANE MULTIPORT SAFETY EXHAUST OUTLET VALVE is designed to release steam and prevent the accumulation of pressure in exhaust steam heating systems, surface condensers, etc. The use of a number of small disks instead of one large disk results in less danger of sticking, larger discharge opening and reduced weight and travel of disk. The position of the disk and the pressure are readily adjusted by a pressure plate to suit the degree of back pressure required, there being no heavy weights to lift. Send for *Engineering Leaflet No. 11.*



Cochrane Multiport Safety Exhaust Outlet Valve

ENGINEERING SERVICE

Write us concerning the conditions in your plant, and the changes contemplated, and we shall be glad to give suggestions as to the best arrangement of apparatus to secure the results desired. We have had twenty years of experience with steam plants aggregating 10,000,000 H.P.

Address Eng. Dept., Harrison Safety Boiler Works, 3199 N. 17th St., Phila., Pa.

THE NATIONAL PIPE BENDING CO.

Boston Office
54 High Street

Main Office and Works
NEW HAVEN, CONN.

New York Office
149 Broadway

THE NATIONAL COIL OR CLOSED FEED-WATER HEATER. THE NATIONAL DIRECT CONTACT FEED-WATER HEATER AND PURIFIER. NATIONAL STORAGE HEATERS, NATIONAL STEAM AND OIL SEPARATORS, COILS AND BENDS OF IRON, BRASS AND COPPER PIPE

THE NATIONAL COIL (OR CLOSED) FEED-WATER HEATER

It consists of from one to fourteen coils of seamless drawn brass or copper tubing incased in a cast-iron or steel shell to which the exhaust steam is admitted, heating the water which passes through the coil or coils.

Nowhere does the feed-water come in contact with the shell.

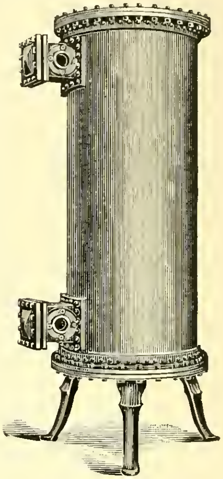
At no time is the shell subject to boiler pressure, that being confined entirely to the tubing.

Consequently the shell neither corrodes nor leaks, nor wears out, and water having no corrosive action on brass or copper, and all joints being brazed the tubing also remains perfectly tight.

Up to and including No. 10 (or from 5 to 100 horsepower) a single coil is used. Above that size there are from two to fourteen coils, connected both at inlet and outlet with a manifold fitting, giving the same flow of feed-water. By this division of the water it is more intimately surrounded with the exhaust steam and much more quickly heated.

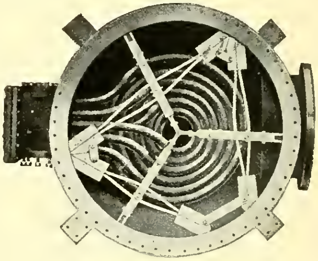
All coils are guaranteed to stand 600 pounds pressure.

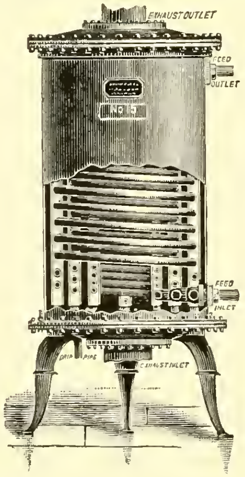
They are connected with special gun-metal manifolds, the ends of the coils being inserted and brazed in, except in large units, where ends are expanded into outside feed nozzles. The coils are secured with braces designed for the purpose, which, while allowing for contraction and expansion, insure rigidity.


National Feed-Water Heater
Type for large units

The area of the shell being in excess of that of the exhaust pipe, no back pressure is ever possible. Neither is there any chance for grease in the boiler.

These and other advantages (including economy of space) which will suggest themselves to the mind of every intelligent engineer, make the National Feed-Water Heater practical, economical in space required, work accomplished and price.



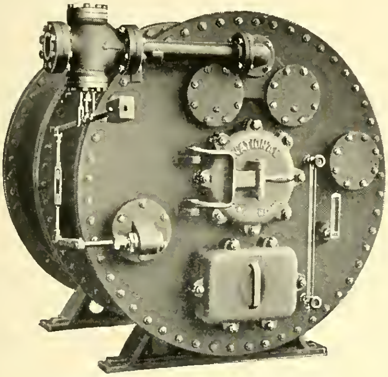


SUMMARY OF MERITS

No inside joints to leak. No straight tubes to leak. No back pressure is possible. *No contact of the water with the shell. No chance for grease in the boiler.* Economy of coal is assured. Economy of space is assured. Economy of price is assured. Our record is 3,250,000 horse-power in daily use. Over 1000 central and electric stations supplied. Hundreds of our heaters show a record of 210 to 212 degrees Fahrenheit.

THE NATIONAL DIRECT CONTACT FEED-WATER HEATER AND PURIFIER

This apparatus is correct and simple in design, very efficient in operation, and of moderate cost, taking into consideration the high quality of material and workmanship.



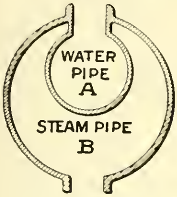
National Direct Contact Feed-Water Heater and Purifier.

METHOD OF TRANSMITTING HEAT FROM EXHAUST STEAM TO THE WATER

From a regulating valve, the water enters a manifold cast on the front head of the heater which serves as a distributing chamber to the contact pipes, which consist of a double cast-iron pipe cast together one within the other, and closed at opposite ends.

The water pipe (A) has a port extending its full length upwards to the outside surface of the steam pipe with vertical walls isolating one from the other.

The Steam Pipe (B) has a port its full length at the bottom, through which all the steam must pass to enter the Heater.



Section of Contact Pipe

The water entering the water pipe flows upward through the port and passes in a thin film over the entire outer surface closely all the way around, until it reaches a rib projecting from each side of the port opening at the bottom of the steam pipe, where it is broken up into two sheets of fine spray.

The steam after passing through the Oil Separator enters the steam pipe, and the only outlet for the steam is the port at the bottom.

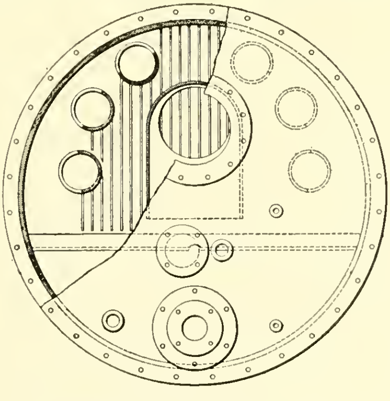
The Cold Water Pipe, being inside of the Steam Pipe, is surrounded by steam and the coldest water and hottest steam are first brought together through contact with the thin walls of the Water Pipe, then the pre-heated water is further heated as the thin film of water passes over the outer surface of the steam pipe, and finally all of the water and all of the steam are brought into direct and actual contact.

THE OIL SEPARATOR

The Oil Separator is part of the Heater and forms the back head and is of the same diameter as the shell. It is of the gravity type, having a multi-ported baffle plate, each port having an individual baffle.

These individual baffles are obtained by having an opening in the back of pipes which extend from the ports in baffle plate to the outer wall of the Separator. They absolutely prevent oil from being carried into the heater. The large cubical capacity of the Separator not only insures the effective separation of oil from the exhaust steam, but it also overcomes the pulsations of exhaust and gives an even flow of steam to the heater.

Upward filtration is used. A large sediment chamber in the bottom of heater relieves filter bed of unnecessary work. A quick-opening blow-off valve on outlet from sediment chamber affords opportunity for draining heater and also causes a reverse current through filter bed, giving it longer life.

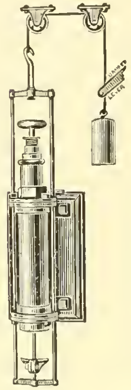


Oil Separator (Part of the Heater itself).

JULIAN D'ESTE COMPANY

24 CANAL ST., BOSTON, MASS.

BRASS FOUNDERS, FINISHERS AND MACHINISTS, SOLE MANUFACTURERS OF CURTIS ENGINEERING SPECIALTIES, INCLUDING DAMPER REGULATORS, IMPROVED PRESSURE REGULATORS, IMPROVED PUMP REGULATORS, WATER PRESSURE REGULATORS, EXPANSION TRAP, RETURN STEAM TRAP, BALANCED STEAM TRAP, RELIEF VALVE FOR STEAM AND WATER, STEAM SEPARATOR, TEMPERATURE REGULATOR, PUMP GOVERNOR AND PUMP, BLOWER VALVE, CELLAR DRAINER, U. S. BALL COCK, ETC.



Damper Regulator

THE CURTIS IMPROVED (PATENT) DAMPER REGULATORS

The plunger is operated by steam direct from the boiler, and the whole pressure in the boiler is therefore available to operate the damper if needed. In practice, only enough pressure is used to lift the weight, usually not more than ten pounds to the square inch on the plunger.

The motion of the damper will begin to change from one direction to the other on a variation of steam pressure of one half of a pound either way from the point at which it is set to operate.

We guarantee a saving of ten per cent of the fuel over the best hand regulation or the old style (diaphragm and lever regulator), and it often reaches fifteen per cent.

They are sent on thirty days' approval and will pay their cost by the saving of fuel in one year. *Three Standard Sizes.*

IMPROVED STEAM PRESSURE REGULATORS

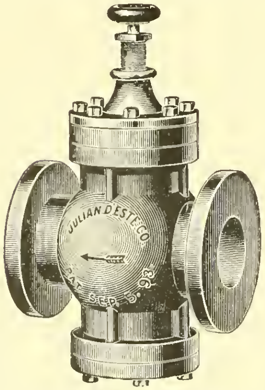
This regulator is made entirely of metal, occupies the same space as a globe valve for the same size pipe, and is very simple and sensitive.

By its use steam may be maintained at high pressure in boilers, and yet be reduced for heating to two or three pounds.

In the best engineering practice the exhaust steam of the engine and elevator is turned into the heating system of a building, and the Regulator automatically supplies just the amount lacking to maintain constant pressure in the pipes and radiators.

Standard sizes for 1, 1¼, 1½, 2, 2½, 3, 4, 5, 6, 7, 8, 10, 12, 14, and 16 inch pipe.

A lockup top furnished at small additional cost.

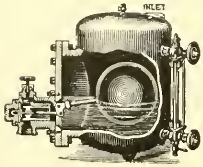


Steam Pressure Regulator

THE CURTIS BALANCED STEAM TRAP

Some Points of Superiority

1. A perfectly balanced valve.
2. An absolutely frictionless valve.
3. The valve can be removed without breaking a joint, starting a gasket, or taking out a bolt.
4. The valve being frictionless and balanced, the whole power of the float is available for opening and closing the valve.
5. The copper float is perfectly spherical, hard, as hermetically sealed as a glass globe, is of uniform thickness and warranted strong and tight at 250 lbs. pressure.
6. It has a pass-by valve to insure constant operation.
7. Each trap will operate perfectly on pressures varying from one to 250 pounds.



Balanced Steam Trap

PRICE LIST

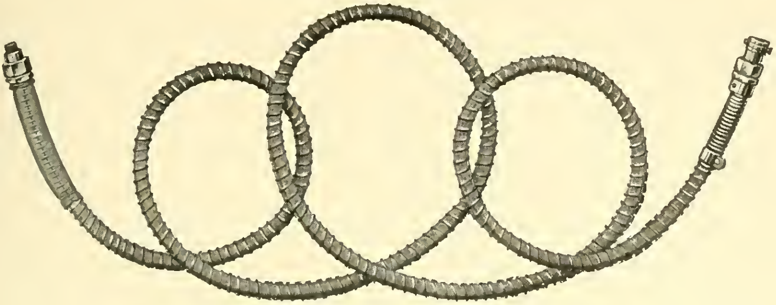
Size and Condensing Capacity in Feet of One-Inch Pipe

No. 000,	$15.00	for	1,000 feet	½	in. inlet and outlet
No. 00,	20.00	for	2,000 feet	½	in. inlet and outlet
No. 0,	25.00	for	3,000 feet	½	in. inlet and outlet
No. 1,	30.00	for	5,000 feet	¾	in. inlet and outlet
No. 2,	40.00	for	8,000 feet	1	in. inlet and outlet
No. 2½,	55.00	for	15,000 feet	1¼	in. inlet and outlet
No. 3,	75.00	for	30,000 feet	1½	in. inlet and outlet
No. 4,	100.00	for	40,000 feet	2	in. inlet and outlet
No. 5,	125.00	for	60,000 feet	3	in. inlet and outlet

THE AMERICAN METAL HOSE CO.

WATERBURY, CONN.

FLEXIBLE METAL HOSE AND TUBING FOR STEAM, OIL, AIR, GAS, WATER, ETC.



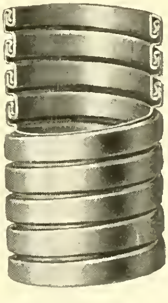
25-foot length 1-inch BD20 Bronze Steam Hose, with packed couplings, re-enforced ends, and one end asbestos and canvas covered.

AMERICAN FLEXIBLE METAL HOSE is particularly adapted to conveying Oil and Steam, both of which quickly attack and destroy Rubber Hose. Our Hose is as strong in construction as is consistent with flexibility, will stand high pressures, and for conveying either of the above agents is most practical and economical. For both of the above purposes an Interlocked Hose is supplied, which is made from a continuous metal ribbon or strip wound spirally over itself, the edges being crimped or turned in during the winding to form the Interlocked Joint shown in illustration; a specially prepared asbestos cord fed into a separate groove in the strip during the winding acting as a packing and making the Hose tight.

For STEAM, our Standard is the Bare Interlocked Pattern, BD15 BRONZE HOSE with I. P. T. Brass Couplings attached. These Couplings are threaded internally to screw onto the spiral groove on the outside of the Hose and are packed on with a stuffing box of asbestos and red lead, making a tight connection. Each coupling is provided with a Flexible Metal re-enforced end which is fastened under a shoulder prepared for it on the Coupling and extends a short distance from the Coupling over the end of the Hose, giving a double thickness of metal at the point where there is the greatest strain.

FLEXIBLE STEEL HOSE, Style BD15 is admirably adapted to conveying Oils, its life being actually prolonged by contact with them. The smaller sizes are used in numberless connections, the principal one being for Oil Feed purposes on machinery. The larger sizes are used extensively in unloading and barrel filling work. Couplings for Oil Hose are generally sweat on.

While the Bare Interlocked Hose, Style BD15, is suitable for ordinary work and pressures, there are instances, when the Hose is subjected to constant handling, where a stronger type is required. To meet this demand we supply our BD20 Hose, which is covered with a braiding of fine BRONZE or STEEL Wire and a Spiral Armor Wire. This covering does not affect the flexibility of the Hose, but is most efficient as a protection where hard usage is unavoidable, and by reason of its greater strength makes the Hose suitable for higher pressures.



Interlocking Construction B. D. 15 Hose

SIZES

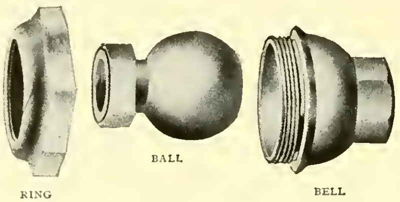
We carry BD15 and BD20 HOSE in stock, both in STEEL and BRONZE in the following sizes: $\frac{3}{16}''$, $\frac{1}{4}''$, $\frac{5}{16}''$, $\frac{3}{8}''$, $\frac{1}{2}''$, $\frac{3}{4}''$, 1″, $1\frac{1}{4}''$, $1\frac{1}{2}''$, 2″, $2\frac{1}{2}''$, and 3″ internal diameter. Larger sizes furnished on order.

Full information on our FLEXIBLE METAL AIR and WATER HOSE and GAS TUBING, or on Special Hose for extreme pressures, furnished on application.

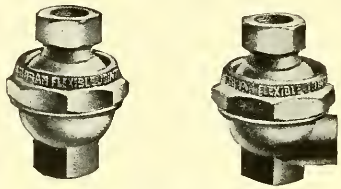
MORAN
FLEXIBLE STEAM JOINT CO., INC.

LOUISVILLE, KY.

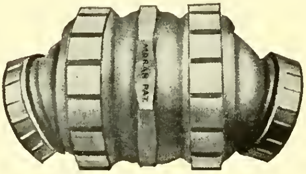
THE MORAN FLEXIBLE JOINT FOR STEAM, AIR, GAS OR LIQUID



Only three parts, no Packing, no Springs, from ⅛ inch to 48 inches



Loose until pressure is applied which automatically tightens joint



Moran Double Flexible Joint

24 in. Moran Flexible Joint, tight and flexible under any pressure

ADVANTAGES OF THE MORAN FLEXIBLE JOINT

Only three parts, all metal. No gasket or packing to be renewed. Almost indestructible. Positively tight under all pressures. Guaranteed against all defects in material and workmanship. The first cost is the only cost.

APPLICATIONS

The Moran Joint takes the place of steam hose for the following work: Temporary Steam Lines, Gun Feed, Steam Niggers, Steam and Air Hammers, Car Heating in Stations, Hydrostatic Test of Boilers, Steam Coils in Tank Cars, Steam Syphons and other connections on Boats, Testing Blocks, Steam Plows, Cross Tie Machines, Locomotive Stokers, Turn Tables, Flue Blowers, Pile Drivers, Coal Hoists.

PRICE LIST OF MORAN FLEXIBLE JOINTS

Discount to trade. Send for catalog.

For Pressure of 200 to 1000 lbs.	Straight	Angle
½ inch	$4.50	$5.00
¾ "	5.50	6.00
1 "	6.50	7.00
1¼ "	7.00	7.50
1½ "	7.50	8.00
2 "	9.00	9.50

Prices given on Application for Brass or Bronze Joints from ¼ to 15 inches.

Pressure 200 lbs. or Less	No. 1 and 3 Straight	No. 2 Angle
Inch		
⅛ Standard Thread	$ 2.75	$3.00
¼ Standard Thread	3.00	3.25
⅜ Standard Thread	3.00	3.25
½ Standard Thread	3.25	3.50
¾ Standard Thread	3.75	4.00
1 Standard Thread	4.25	4.50
1¼ Standard Thread	5.25	5.50
1½ Standard Thread	6.00	6.25
2 Standard Thread	7.50	8.75
2½ Standard Thread	9.00	10.50
3 Standard Thread	11.25	12.25
3½ Standard Thread	14.00	15.50
4 Standard Thread	15.00	16.75
4½ Standard Thread	18.75	20.75
5 Standard Thread	18.75	20.75
6 Standard Thread	25.00	27.50
7 Threaded or Flanged	50.00	55.00
8 Threaded or Flanged	55.00	65.00
9 Threaded or Flanged	90.00	100.00
10 Threaded or Flanged	100.00	120.00

Larger sizes furnished for either hub and spigot Flanged or Threaded connections. In ordering, please state whether steam, air or liquid is to be conveyed, and under what pressure.

PRICES GIVEN FOR SAME ON APPLICATION

ALL PRICES F. O. B. LOUISVILLE, KY.

THE CHAPMAN VALVE MFG. CO.

INDIAN ORCHARD, MASS.

STEEL PARALLEL SEAT, DOUBLE GATE VALVE FOR SUPERHEATED STEAM
STEEL BODIES AND BONNETS, MONEL METAL GATES AND SEATS

STRAIGHTWAY TYPE

Fig. 312 is a cut of the internal working parts, showing the carrier block extended to carry an opening the full size of the pipe line, so that when the valve is fully open the seats are covered and the pipe line is made continuous, the carrier extension effectually filling up the aperture around the seats.

The valve when open is the same as if it were a continuation of the pipe line, with neither contractions or apertures of any kind to deflect or break up the flow of the steam. This construction not only prevents the loss of head due to eddying, but it also protects the seats from injury.

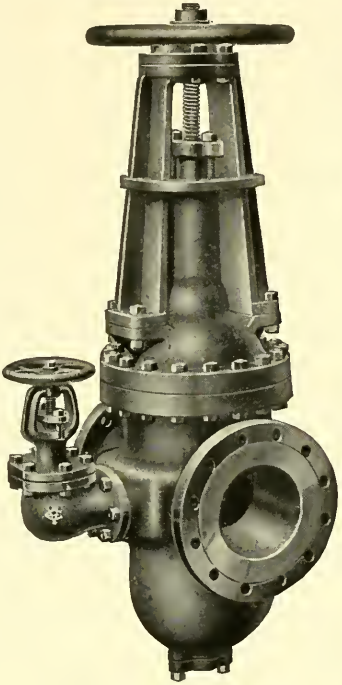


Fig 311

Diameter of Port or Size = A
Face to Face Flanges = B
Diameter of Flanges = C

A	2	2½	3	3½	4	4½
B	10¼	12½	14	14¾	18½	18½
C	6½	7½	8¼	9	10	10½

A	5	6	7	8	9	10
B	18½	19	20	20⅝	21⅞	22¾
C	11	12½	14	15	16	17½

A	12	14	16	18	20	24
B	23¾	25⅞	32⅞	33¼	35¼	35⅞
C	20	22½	25	27	29½	34

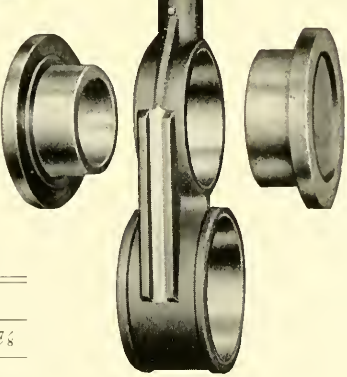


Fig 312

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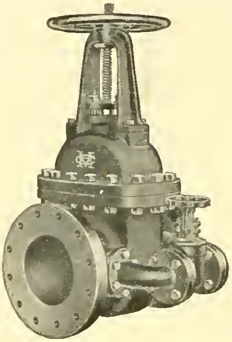
MONARCH VALVE AND MFG. CO.

SPRINGFIELD, MASS.

NEW YORK BOSTON CLEVELAND

HIGH GRADE VALVES FOR STEAM, WATER, GAS, AIR, OIL, AMMONIA, BRINE, ETC. MADE OF THE BEST STEAM BRONZE, GRAY IRON OR STEEL.

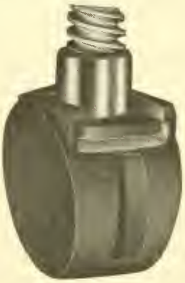
The table below gives a partial list of our regular product.

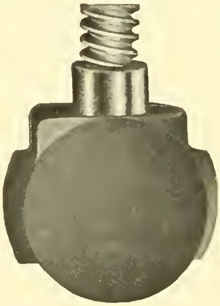


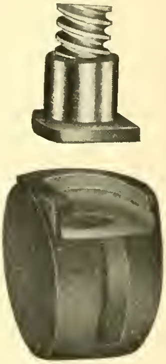
LIST	DESCRIPTION
1	Bronze Gate, 125 lbs. Steam, 250 lbs. Water Pressure.
2	“ “ 250 “ “ 400 “ “ “
3	“ “ 800 “ Water Pressure.
4	“ “ 2000 “ “ “
5	“ “ 6000 “ “ “
6	“ Globe, 125 “ Steam, 250 lbs. Water Pressure.
7	“ “ 250 “ “ 400 “ “ “
8	“ Check, 125 “ “ 250 “ “ “
9	“ “ 250 “ “ 400 “ “ “
10	“ Navy, 50 “ Pressure.
11	“ “ 300 “ “
12	“ “ 500 “ “
15	Iron Body Gate, 80 lbs. Steam. 150 lbs. Water Pressure.
16	“ “ “ 125 “ “ 200 “ “ “
16¼	“ “ “ 150 “ “ Pressure.
17	“ “ “ 250 “ “ 400 lbs Water Pressure.
18	“ “ Globe, 80 “ “ 150 “ “ “
19	“ “ “ 125 “ “ 200 “ “ “
20	“ “ Check, 125 “ “ 200 “ “ “
21	“ “ “ 250 “ “ 400 “ “ “
22	Steel “ Gate, 250 “ “ 400 “ “ “
23	“ “ Globe, 250 “ “ 400 “ “ “
24	“ “ Check, 250 “ “ 400 “ “ “

THE MONARCH LOOSE NECK GATE

The cuts below illustrate our method of connecting gate and spindle. The spindle is threaded into a third member, which fits into a slot at the top of gate. There is a slight amount of play between these parts, so that the gate closes without catching or binding, and without uneven wear or side strain on spindle.







THE DARLING PUMP & MFG. CO. Ltd.

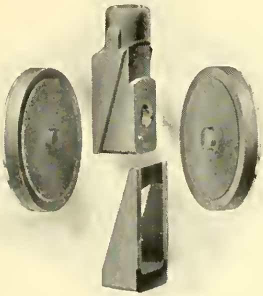
WILLIAMSPORT PA.

Sales Offices:

New York City, 149 Broadway
Chicago, The Rookery

Philadelphia, Arcade Building
Boston, 141 Milk Street

DARLING GATE VALVES, FIRE HYDRANTS INDICATOR POSTS, FLOOR STANDS, VALVE BOXES, BALL CHECK VALVES, MADE FOR ALL PRESSURES AND PURPOSES



Wedging Mechanism—Shown with Parts Separated

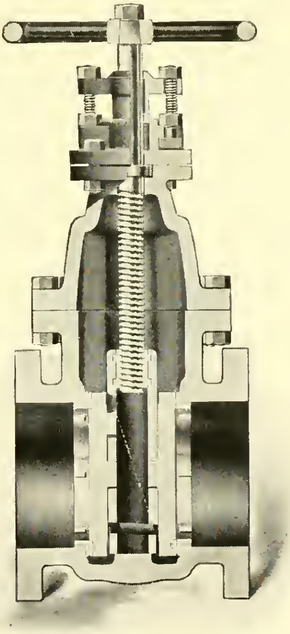
The Darling Patented Gate Valve has Parallel Seats, Double Revolving Gate Discs and Compound Equalizing Wedges. The Wedging Mechanism operates Between the Gate Discs and Independent of them.

The Gate Discs being plain, no portion of the Wedging Mechanism is formed upon them. These Gate Discs revolve independently of the wedges, and independently of each other. The Revolving Gate Discs change their positions on the Seats each time the Valve is closed, thus distributing wear equally over entire Faces of Gates and Seats, ensuring Durability.

Gates Released Before Opening, Avoiding Wear on Seats.

Cannot Stick or Bind.

Simple, Reliable, Durable.

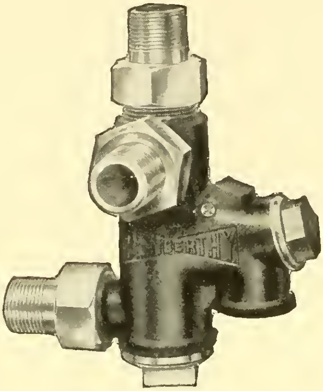


Sectional View of Inside Screw Valve with Flanged Ends

PENBERTHY INJECTOR CO.

DETROIT, MICH., U. S. A.

INJECTORS, EJECTORS, WATER GAGES, AUTOMATIC CELLAR DRAINER, STEAM SPECIALTIES, ETC.



PENBERTHY AUTOMATIC INJECTORS

Start Low—20 to 22 lbs. steam on 3 feet lift.

Work High—165 to 170 lbs. steam on 3 feet lift.

Lift Water—20 to 24 ft. on 60 to 80 lbs. steam.

Handle Hot Water—125 deg. to 135 deg. at 60 to 80 lbs. steam.
115 deg. to 120 deg. at 100 lbs. steam.
95 deg. to 104 deg. at 125 lbs. steam.

Hot Water Delivered.

The Penberthy delivers water to boiler at 160 deg. to 212 deg. Fah. according to temperature of feed water and steam pressure, but 200 deg. to 212 deg. can always be delivered at nearly all pressures over 50 lbs. by throttling suction valve and delivering the minimum capacity.

Automatic Qualities.

By this we mean that when the Injector is working and forcing water to the boiler, if the current of water be suddenly broken by any cause, the Injector will pick up the water and again establish the current to the boiler automatically, without the manipulation of a single valve or the least attention from an attendant.

XL-96 EJECTOR

For Lifting and Elevating Liquids.

Lifts—22 to 25 feet.
Elevators—25 to 100 feet.

Heretofore, in order to obtain an elevation of liquids of 50 to 65 feet, the lifting power has been sacrificed, so that, with other Ejectors, the lifting power has been a second consideration, and in order to elevate water 50 to 65 feet, the Ejector had to be placed near the water and high pressure carried. With the XL-96 we lift water 20 feet with any steam pressure above 25 lbs. and 25 feet with pressure at 40 lbs. or over. On pressure above 80 lbs., steam must be throttled to get best results on a lift. Besides doing this, we elevate 50 feet at 60 lbs. pressure and 65 to 100 feet on pressure 50 to 100 lbs. by placing the Ejector within 12 or 18 inches of water supply.

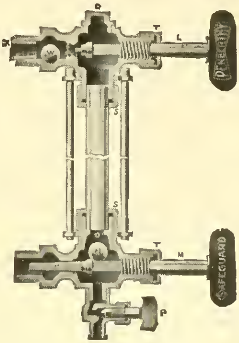
Ejectors for Special Requirements.

The principle and power contained in so small, handy and economical an instrument continually suggests new uses of the Ejector which uses often demand that the tubes of Ejector be proportioned particularly for the service, respecting which we have perfected and carry in stock special Ejectors singularly efficient in the work for which they are designed.

PENBERTHY INJECTOR CO.

SAFEGUARD AUTOMATIC WATER GAGE

Mechanically Correct



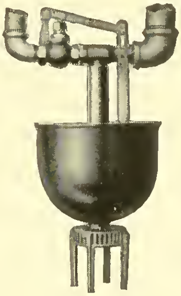
PAT. APPLIED FOR

Sectional View of Safeguard Automatic Water Gage

The upper seat is designed to leak for purposes solely of sureness of operating at the proper time. Only dry steam escapes and in small quantity, hurting no one. The leak equalizes the pressure in the glass and the boiler pressure and the BALLS CANNOT STAY SEATED UNLESS GLASS IS BROKEN. This fact is positive, and any gage not made to leak on the upper arm is unsafe.

The lower seat is made absolutely tight, and when glass breaks, the ball seats instantly, AND NOT A DROP OF WATER AND NO STEAM ESCAPES to injure anyone. Fitted with Penberthy Patented Dripless Pet-Cock.

AUTOMATIC CELLAR DRAINER



The Penberthy Automatic Cellar Drainer is the combination of a Penberthy Water Pressure Ejector of high capacity, and an automatically operated, float-controlled, quick-opening-and-closing valve. This valve is never partially opened—it cannot leak, and it allows the Ejector to give its greatest efficiency by working to full capacity. The float arms are slotted where they connect to the valve lever—this prevents the Ejector from operating until the water has raised to the highest point, and, as the water is ejected, they travel down the length of these slots before the weight of the float affects the valve. This allows the machine to work for longer periods and not so often, thus preventing considerable wear and the leakage and dribbling of water, as is so common in the majority of drainers.

To enable the installation of this drainer in small pits, or sumps, we have made it as compact as possible. The float, instead of being round, is flat on the top; it has more buoyancy than a round float of the same diameter. We have further economized on space by building the float around the suction pipe. This patented feature has the added advantage of being rigid and overcomes all the trouble of the common loose float. The balance of the drainer is built directly above the float; this not only keeps the whole machine in as small a space as possible, BUT ALSO KEEPS ALL WORKING PARTS, WITH THE EXCEPTION OF STRAINER, SUCTION PIPE AND FLOAT, ABOVE THE WATER.

ALUMINUM COMPANY OF AMERICA

PITTSBURGH PENNA.

BRANCH OFFICES

New York, 99 John Street
Boston, Mass., 131 State Street
Pittsburgh, Pa., 2344 Oliver Bldg.
Cleveland, O., 719 Garfield Bldg.
Detroit, Mich., 1515 Ford Building
Chicago, Ill., Old Colony Building

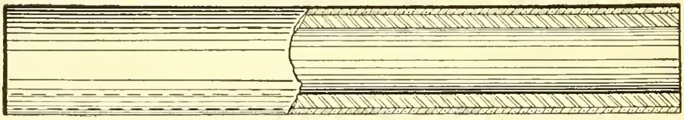
Rochester, N. Y., 406 Powers Bldg.
Philadelphia, Pa., 320 Witherspoon Bldg.
Washington, D. C., 514 National Metropolitan Bank Bldg.
Toronto, Ont., Northern Aluminum Co., Ltd., 1503 Traders Bank Bldg.

Pierson, Roeding & Company, 118 New Montgomery St., San Francisco, Cal.

ALUMINUM

INGOT
SHEET
CASTING ALLOYS
ELECTRICAL CONDUCTORS
RODS
MOULDINGS
TUBE
FITTINGS
BRONZE POWDER
LITHOGRAPH PLATES

BIMETALLIC CONDENSER TUBES



Bimetallic tubes, composed of a copper envelope over an aluminum lining (or vice versa), possess longer life without pitting and leaking than any other tubes when used with cooling water high in sulphuric acid and sulphates. They also stand high in the scale of heat conductivity.

FABRICATED ALUMINUM

Kettles, tanks, coolers, evaporators, pipe lines and miscellaneous apparatus for chemical, soap, candle and stearic acid manufactures, also for preserving and brewery processes.

ALUMINUM CABLE FOR TRANSMISSION OF ELECTRICAL ENERGY

Joints of aluminum cable and feeders can be made easily, cheaply and satisfactorily.

CRESCENT MANUFACTURING CO.

SCOTTDALE, PA.

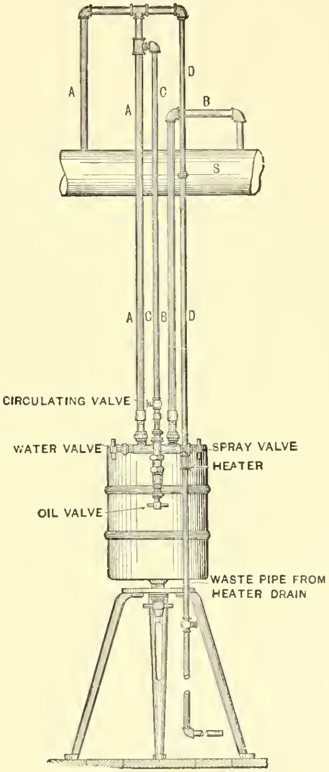
LACKAWANNA SIGHT FEED LUBRICATORS
AND AUTOMATIC GREASE CUPS

LACKAWANNA LUBRICATORS

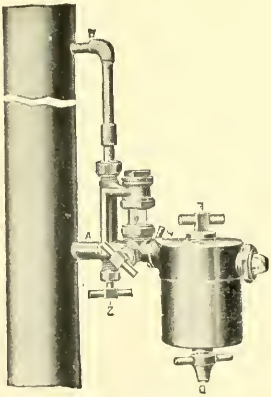
This device is designed to furnish lubricant to a series of cylinders from the one supply, and we have hundreds of endorsements as to its convenience and economy as compared with the use of individual lubricators for each cylinder. Its special circulating pipe keeps a constant flow of fresh water through the sight glass, and the heating attachment keeps the oil at a uniform temperature. Our patent spray valve vaporizes the oil and thoroughly impregnates the steam with lubricant.

Full instructions covering operation of 5-gal. lubricator are sent with each machine.

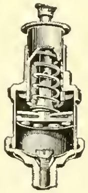
Card supplied with each lubricator shows connection made to overhead steam line. Blue print furnished, where connection has to be made to perpendicular line, or where steam line runs below floor level.



5-Gallon Series Lubricator



Stationary Lubricator



Grease Cup

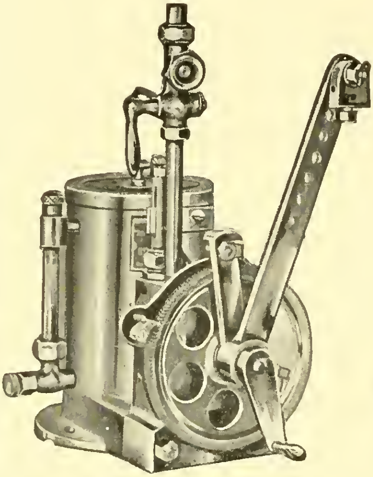
LOCOMOTIVE - - - - - - -	1 Qt.—1½ Qt.—2 Qt.
STATIONARY - - - - -	½ Pt.—1 Pt.—1 Qt.—2 Qt.—5 Gal.
GREASE CUPS - - - - - -	½ oz., 1, 2, 4, 6 and 8 oz.

GREENE, TWEED & CO.

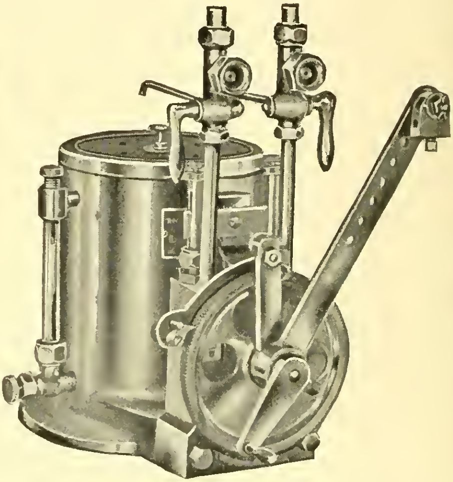
109 DUANE STREET, NEW YORK

MANUFACTURERS OF THE

ROCHESTER AUTOMATIC LUBRICATOR



Single Feed



Double Feed

The Lubricator, in the manufacture of which no expense has been spared, efficiency and high quality being our aim rather than low prices.

For the lubrication of the cylinders of all types of steam engines and pumps as well as air and ammonia compressors.

Made in all sizes from one-half pint to two gallon and with any number of feeds from one to eight. Also made with two compartments, for use where different kinds of oil are used in the different cylinders of the same machine, such as air compressors, ice machines, etc.

Finish-all sizes above one-half pint fully nickel-plated, one-half pint size, japanned body.

Working parts are made of steel, and all bearings are case hardened.

All the mechanism can be instantly detached and removed, giving easy access to the working parts for cleaning, repairing, etc., without disturbing the bowl or reservoir attached to the engine.

Equipped with Multiplus Sight Feeds, and vacuum and check valves.

Each feed is regulated independently.

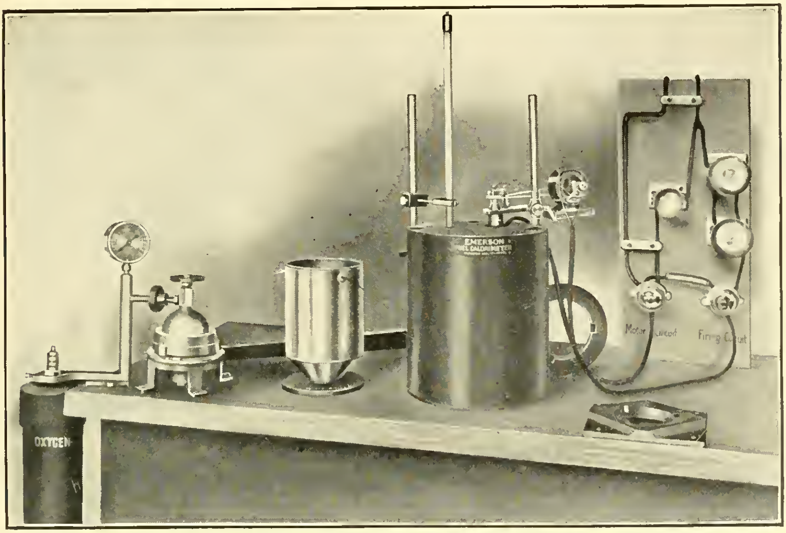
Not affected by temperature, pressure or vacuum.

"PERFECT FORCE FEED LUBRICATION"

EMERSON APPARATUS COMPANY

BOSTON, MASS.

MANUFACTURERS OF TECHNICAL APPARATUS, EXPERIMENTAL AND OTHER HIGH GRADE MACHINE WORK



The Emerson Fuel Calorimeter

THE EMERSON FUEL CALORIMETER

THE LEADING APPARATUS FOR THE DETERMINATION OF THE HEAT VALUE OF COAL, COKE, FUEL OIL, AND GASOLINE, ETC.

ITS PRACTICAL APPLICATION

First.—The calorimeter makes possible the purchase of fuel on the specification or heat unit basis with its many attendant beneficial results.

Second.—As a power plant accessory it operates as a check upon actual results obtained in burning fuel or, in other words, upon the efficiency and economy of operation.

THE EMERSON FUEL CALORIMETER IS RECOMMENDED AS PROFITABLE FOR CONSUMERS USING TWO THOUSAND TONS OR MORE OF COAL PER YEAR.

APPARATUS

The apparatus required is shown in the cut above, and comprises chiefly a steel bomb, calorimeter can, double wall calorimeter jacket, motor driven stirring device, heavy piping to oxygen tank, large wrench, plate holder and swivel table, etc.

Complete information, including prices, method of operation, etc., given on request.

TRIUMPH ELECTRIC COMPANY

CINCINNATI, OHIO, U. S. A.

MOTORS, GENERATORS, TRANSFORMERS AND OTHER ELECTRICAL EQUIPMENT

ADJUSTABLE SPEED, COMMUTATION POLE MOTORS, FOR DRIVING MACHINE TOOLS AND OTHER MACHINERY

These motors are built in all standard sizes from ½ H.P. upwards, and with speed variations of 1 to 2, 1 to 3, and 1 to 4, which are the ratios generally called for by machine tool manufacturers.

The special features of The Triumph Adjustable Speed Commutation Pole Motors are enumerated below:

(1) Wide Adjustment of Speed.

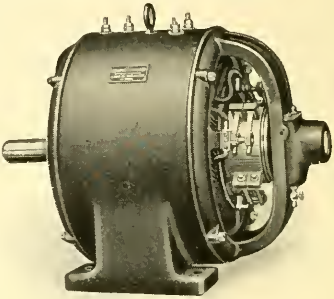
(2) Constant speed maintained at any given speed.

(3) Constant output at any speed.

(4) Heavy overload capacity.

(5) Sparkless commutation at any load.

(6) Motors will run without sparking at any speed or load within the capacity of the motor, and in either direction of rotation without shifting the brushes, which are immovably fixed.



Adjustable Speed Motor with field control

CONSTRUCTION

The construction is practically identical with that of our well-known Constant Speed Motors, with the exception that Commutation poles are placed midway between the main field poles and are firmly bolted to the field yoke. These poles are formed of the best quality wrought iron, and are carefully wound and insulated.

The coils are in series with the armature circuit so that the strength of these poles depends upon the load on the motor, and is therefore proportional to the armature reaction. This is true irrespective of the direction of rotation, so that the points of commutation are always in a field of such magnetic strength that sparkless commutation at all loads and all speed variations is obtained.

This method of construction permits heavy overloads to be carried with ease and safety.

Aside from efficiency and other important operating characteristics, the mechanical construction and appearance of any motor is of paramount importance. Our motors are exceedingly strong and durable, of light weight, and present a very symmetrical and pleasing appearance. We mention these points because it is evident that a motor of light weight, durable construction, high efficiency, heavy overload capacity, and having also a compact and symmetrical appearance must necessarily be a high grade machine.

SERVICE

The absolutely sparkless operation of these motors insures long life for the commutator, smooth running for the motor, and less wear and tear on the brushes.

The advantages of the commutation pole type of motor are many, and include, in addition to above:

(1) Less heating generated in the commutator.

(2) Higher efficiency, due to the lower iron and commutator losses.

(3) Due to the sparkless commutation, less carbon and copper dust is deposited on the motor, which is therefore cleaner and less liable to burn-outs.

TRIUMPH BULLETINS

The following bulletins are in force at the present time, any of which will be sent on request; 371 Adjustable Speed Motors, 381 Printing Press Motors, 391 Direct Current Constant Speed Motors, 401 Triumph Generators & Gas Engines, 411 Small Direct Connected Generating Sets, 421 Direct Current Belted Type Generators, 431 Alternating Current Belted Type Generators, 441 Three-wire Generators, 451 Power & Lighting Transformers, 461 Engine Type Direct Current Generators, 471 Polyphase Induction Motors, 481 Engine Type Alternating Current Generators. Directions and formulæ for testing Polyphase Induction Motors.

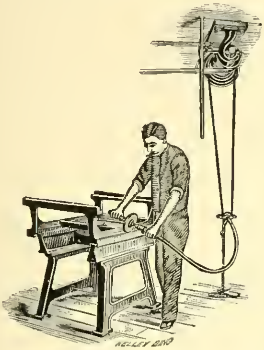
STOW MANUFACTURING CO.

BINGHAMTON, N. Y.

General European Agents, Selson Engineering Company
85 Queen Victoria Street, London, England

THE STOW FLEXIBLE SHAFT. PORTABLE DRILLING TAPPING, REAMING AND GRINDING TOOLS BELT OR MOTOR DRIVEN

Stow Flexible Shaft



PORTABLE EMERY GRINDER

The Portable Emery Grinder takes the tool to the work (instead of the work to the tool), saves time, and enables the user to avoid handling heavy pieces of material.

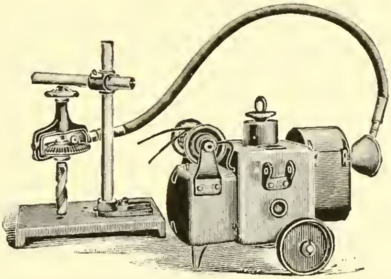
Almost indispensable for cleaning and grinding heavy castings, or for buffing and polishing metals and glass.

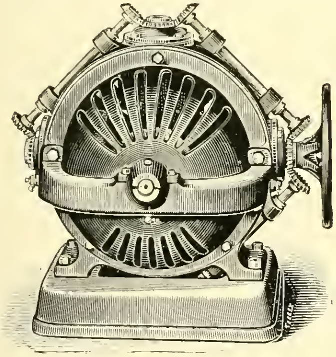
Furnished with either rope or electrical drive.

COMBINATION OF STOW FLEXIBLE SHAFT AND ELECTRIC MOTOR

For drilling, tapping, reaming, etc. Can be arranged for emery grinding, rail drilling, grinding, etc.

Made in four standard sizes suitable for drilling holes $\frac{1}{2}$, 1, $1\frac{5}{8}$ and 2 in. diameter.





MULTI-SPEED MOTORS

These motors are made in both portable and stationary types.

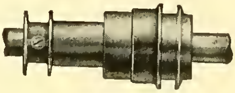
They have a wide range and infinite variation of speeds. A fraction of a turn of the hand wheel shown gives a corresponding change in the speed of the armature. Write for catalog and prices.

THE CARLYLE JOHNSON MACHINE COMPANY

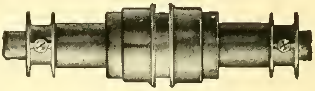
MANCHESTER, CONN., U. S. A.

THE JOHNSON FRICTION CLUTCH

A Small, Compact Clutch for Light Power



Single Clutch-Exterior



Double Clutch-Exterior

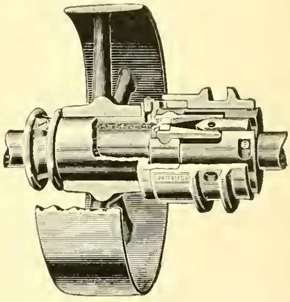
DIMENSIONS OF STANDARD SINGLE CLUTCHES

Clutch Size Number	Horse-power for each 100 R.P.M.	Largest Diameter Clutch will Bore	Throw D to Engage Clutch	Weight of Standard Clutch
2	2	$1\frac{7}{16}''$	$\frac{11}{16}''$	12 lbs.
4	3	$1\frac{11}{16}''$	$\frac{23}{32}''$	19 "
5	4	$1\frac{15}{16}''$	$\frac{23}{32}''$	27 "
6	5	$2\frac{3}{16}''$	$\frac{7}{8}''$	35 "
8	6	$3''$	$\frac{15}{16}''$	53 "

DIMENSIONS OF STANDARD DOUBLE CLUTCHES

Clutch Size Number	Horse-power for each 100 R.P.M.	Largest Diameter Clutch will Bore	Throw D to Engage Clutch	Weight of Standard Clutch
2	2	$1\frac{7}{16}''$	$\frac{11}{16}''$	25 lbs.
4	3	$1\frac{11}{16}''$	$\frac{23}{32}''$	32 "
5	4	$1\frac{15}{16}''$	$\frac{23}{32}''$	43 "
6	5	$2\frac{3}{16}''$	$\frac{7}{8}''$	54 "
8	6	$3''$	$\frac{15}{16}''$	96 "

CONSTRUCTION



Section Broken Away, Showing Clutch Engaged and Pulley Mounted on Hub of Friction Cup

As seen by the illustration, this type of Clutch has but few parts and is very compact. A body fastened to the shaft carries a split ring in which are inserted a pair of levers. A curve-shaped wedge, which is made part of a shipper sleeve, forces the levers apart, expanding the ring, bringing its outer surface into frictional contact with the inner surface of the friction cup, the hub of which is made to suit requirements.

The leverage is so compounded that it requires but little pressure to operate the Clutch.

One screw which moves two taper blocks, set into the levers, adjusts the contact of the ring and cup to any tension. This is easily reached with a screwdriver through hole in the friction cup. The perfectly smooth shipper sleeve entirely covers the working parts so no dirt can get near them. The Double Clutch requires but little more space than the Single, and has two friction cups with hubs, on which can be mounted pulleys, cones, gears, etc., of any diameter and face.

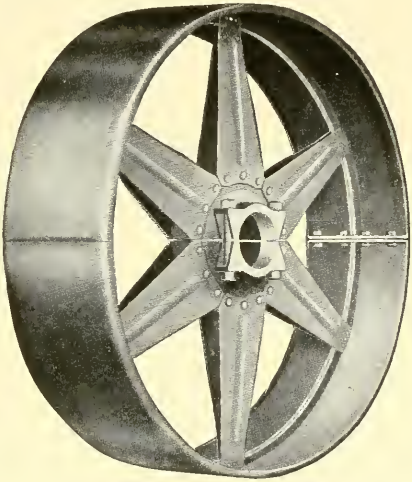
PHILIPS PRESSED STEEL PULLEY WORKS

FOURTH ST. AND GLENWOOD AVE., PHILADELPHIA, PA.

PRESSED STEEL AND CAST IRON SPLIT PULLEY

PHILIPS PRESSED STEEL PULLEY

Distinctive Features



First—THE RIM

The rim having a radius with a perfectly smooth surface allows the belt to hug the entire width of face, transmitting full horse-power of the belt. NO RIVETS OR GROOVES IN THE FACE MEANS GREATER POWER. The ends of the rim being turned inwardly from the face prevents the sharp end of sheets from cutting the belt, the rim lugs extending over the entire width of the face, makes what is a weak point in pulleys a strong joint.

Second—THE ARMS

The arms are of truss construction, making it impossible to center the strain upon any one set of arms, the strain being equally divided over the entire circumference of the pulley rim, thus providing for lateral strain. The arms being placed either side of the hub strengthen the outer edges of the rim and provide for transverse strain.

Third—THE HUB

It is massive and strong, being made of cast iron; is bored and reamed, insuring perfect trueness of fit, and having perfect rigidity makes it impossible to distort it when fastened to the shaft.

Fourth—THE BUSHINGS

Bushings are lathe-turned, made fool-proof, and interchangeable in sizes varying from 1-16 of an inch up to bore of hub.

Fifth—WEIGHT OF PULLEYS

PHILIPS PULLEYS weigh about one half as much as double-belt iron pulleys, and consequently decrease the friction load to that extent.

PHILIPS PULLEYS are equal under all conditions to double-belt cast iron pulleys.

Sizes in Cast Iron	6 to 11″	diameter—	2 to 10″	face	inclusive.
Steel	12 to 36″	"	3 to 12″	"	"
"	38 to 48″	"	6 to 16″	"	"

Can furnish Special Heavy Duty Pulleys with special bores upon application.

ROBINS CONVEYING BELT CO.

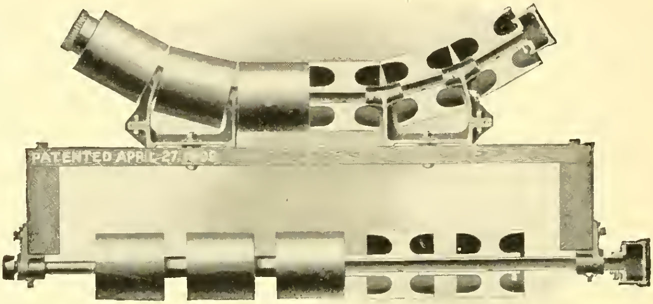
PARK ROW BUILDING, NEW YORK
Chicago San Francisco Spokane
WORKS: PASSAIC, N. J.

CONVEYING, ELEVATING, AND HOISTING MACHINERY

For Handling.

Coal
Coke
Ores
Concrete
Rock
Phosphate
Sand
Gravel
Chips
Earth
Cement
Ashes
Boxes
Barrels
Packages
Trunks
Dishes
Bags

ROBINS STANDARD AND ADJUSTABLE COAL AND COKE CRUSHERS



The most important elements of a Belt Conveyor are the Idlers and the Belt, since on these depends its proper operation as well as the cost of handling. The Robins Patent 5-shaft Troughing Idlers, shown above, are universally accepted as the Standard, being the only ones which embody the following important principles of design:

(1) All the pulleys are in the same *vertical plane.* (2) They have continuous hollow-tube grease-lubrication from end to end. (3) The profile of the idler nearly approaches the arc of a circle, preventing sharp bends in the belt. (4) The idlers are adjustable for properly training the belt. They are made in all sizes from 12″ to 60″.

The Robins Patent Reinforced Conveyor Belt, shown above, has been one of the chief factors of the success of the Robins System. Sixteen years of hard trial, under all kinds of conditions, have demonstrated that it is stronger, runs truer, and gives a greater return for the money than any other belt on the market. This is due to the following peculiarities of construction:

(1) The rubber cover is thickened in the center only, *where the wear is greatest.*

(2) The edges are reinforced by extra plies of duck, increasing the strength and making the belt self-supporting between idler sets.

(3) Being very flexible laterally it conforms closely to the shape of the idlers, and therefore runs true even when empty. With this belt no guide idlers are required.

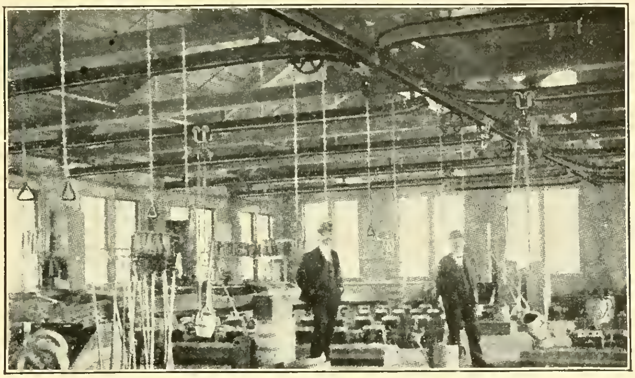
(4) An extra ply of special coarse fibre embedded in the cover and extending around the edges enormously increases the resistance of the cover, and also the adhesion between the cover and the body.

The Robins Monthly Bulletin, containing valuable conveying engineering data, is gladly sent to all interested persons.

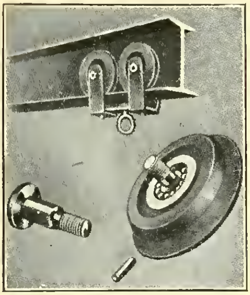
PHILADELPHIA TRAMRAIL CO.

PHILADELPHIA, PA.

OVERHEAD TRAMRAILS FOR FOUNDRIES, MACHINE SHOPS, PRINTING PRESS ROOMS, FACTORIES, STORAGE WAREHOUSES, CANNERIES, ABATTOIRS, PACKING HOUSES, ETC



System of Overhead Tramrail in Brass Foundry



I-Beam Trolley and its Parts

Overhead tramrail, briefly described, consists of an overhead track suspended from the building trusses or joists by means of hangers, and connected at intersecting points by means of switches. On this track can be carried loads of hot metal, castings, rolls of paper, bales, barrels, buckets and boxes of all kinds of material by means of a trolley.

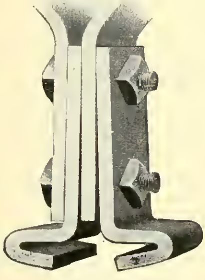
This trolley has anti-friction roller bearing wheels, and operates so easily that a load of 1000 to 2000 lbs. can be moved by one man with very little exertion.

The use of the switches permits the load to be moved to any desired part of the building, as shown in this illustration.

The trolleys are made with two forged steel yokes, swiveled on a bearing plate. The Wheels have crown tread and are roller bearing. The whole trolley swivels to give it ease in turning the curves.

The clamps are forged from steel and of such design as to do away with drilling or punching holes in the tracks. By means of clamps, the hangers are adjusted along the tracks to suit the overhead supports.

The switches are positively "fool proof," having safety locks and guards at the open ends. They are positive in their action and entirely of steel.



The Clamp

WHAT WE WANT YOU TO DO

First.—If possible, send a scale sketch of proposed layout, showing us what you wish to accomplish and your idea of doing it.

Second.—Advise, if possible, the application of the track best suited to your conditions, whether I-beam or flat rail.

Third.—State maximum load to be moved, and whether for constant or occasional use.

Fourth.—Give some idea of the size of loads aside from weights.

Fifth.—State distance from floor to under side of trusses or timbers to which supports for the tracks are to be attached or suspended. Also give distance apart on centers, size of timbers or steel trusses, how constructed, and location of same on plan.

Note.—When possible, it is best to have tracks about 9 feet from the floor, providing it will not interfere with the proper handling of loads.

WHAT WE WILL DO

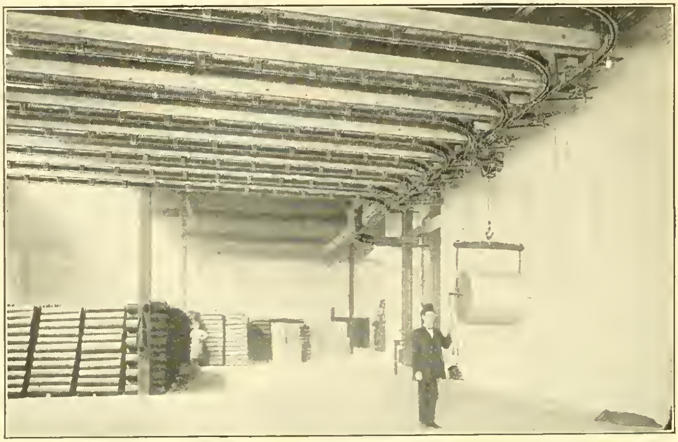
The "Philadelphia Tramrail Company" will send you a detailed working plan of your building, showing the points connected with switches and a Philadelphia Tramrail System accurately located. This information we will be glad to give you. We will tell you what it will cost and how it will save you money.

Send the plan, or favor our representative with an interview.

RICHARDS-WILCOX MANUFACTURING CO.

AURORA, ILL.

OVERHEAD TROLLEY CARRYING SYSTEMS, AUTOMATIC FIRE DOOR FIXTURES; SLIDING DOOR HANGERS FOR WAREHOUSES, FACTORIES, ETC,

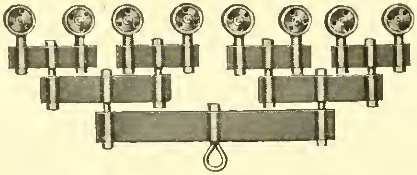


Typical Installation of Richards-Wilcox Overhead Trolley Track

The illustration above shows a typical arrangement of Richards-Wilcox Overhead Trolley Tracks in a large factory. The construction of this track is such that it is impossible for a carrier to drop out, and an ample factor of safety is provided against breakdowns.

Perfect flexibility is assured by a system of switches and turntables which provide for any desired arrangement of tracks.

These switches and turntables are absolutely "Fool-Proof" in that their construction leaves no possibility for carriers to drop no matter how turned or in what position.



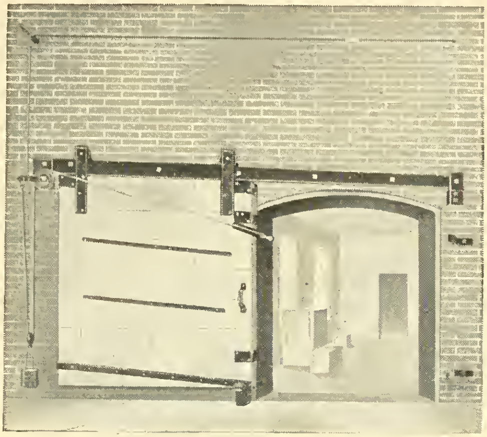
Sixteen-wheel carrier, capacity 4,000 pounds, runs in No. 33 track. Eight-wheel carrier, capacity 2,000 pounds, runs in No. 33 track. Sixteen-wheel carrier, capacity 1,500 pounds, runs in No. 31 track. Eight-wheel carrier, capacity 1,000 pounds, runs in No. 31 track. Four-wheel carrier, capacity 500 pounds, runs in No. 31 track

CARRIERS

Carriers are built with case hardened pendants and rollers in five regular sizes having capacities up to 4000 lbs. as indicated by the table herewith, and can be run around curves of 24″ radius. A larger radius is advised, however, when it can be used

Illustrated catalogs and full information concerning standard or special layouts and designs furnished on request.

RICHARDS-WILCOX MANUFACTURING CO.



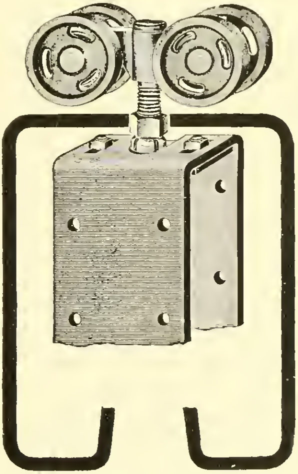
Richards-Monarch Fire Door Fixtures

(Inspected by Underwriters' Laboratories (Inc.) under the direction of the National Board of Fire Underwriters.)

STANDARD 3-PLY TINCLAD FIRE DOOR:—The illustration above shows the manner of applying hardware, and also the arrangement of cord and fusible links. One link is constantly in the opening exposed to both sides of doorway, the other link is above the opening near ceiling. The fusing of either of these links releases the weights and allows the door to close. When doors are used on both sides of wall the cord passes through wall at point where end is attached to screw eye, and continues the arrangement on other side of wall. With this double arrangement four fusible links are exposed. In case any one of the four links fuses, weights will be released and both doors will close.

In some cities local boards prefer to have cord cross opening with link in center of opening. These requirements are met upon application.

SLIDING DOOR HANGERS



This illustration shows one of a large variety of sizes and styles of Richards Sliding Door Hangers.

These are made either with Ball Bearings or Roller Bearings and for doors weighing as much as 2000 lbs.

We also show in this cut a section of the track used for both door hangers and overhead trolleys.

This track is manufactured in 5 standard sizes weighing from 1 lb. to $3\frac{3}{4}$ lbs. per lineal foot. Catalogs on request.

THE RAIL JOINT COMPANY

GENERAL OFFICES:

185 MADISON AVENUE, - NEW YORK CITY

Catalog at Agencies

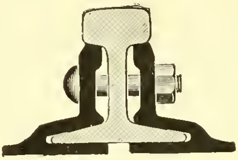
Boston, Mass.	Pittsburg, Pa.
Chicago, Ill.	Portland, Oregon
Denver, Colo.	St. Louis, Mo.

Troy, N. Y.

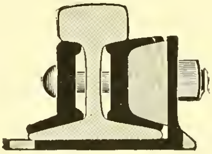
London, E. C., Eng. Montreal, Can.

MAKERS OF BASE-SUPPORTED RAIL JOINTS FOR STANDARD AND SPECIAL RAIL SECTIONS, ALSO GIRDER, STEP OR COMPROMISE, FROG AND SWITCH, AND INSULATED RAIL JOINTS, PROTECTED BY PATENTS.

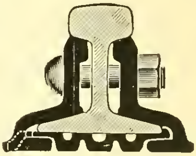
Highest Awards—Paris, 1900; Buffalo, 1901; St. Louis, 1904.



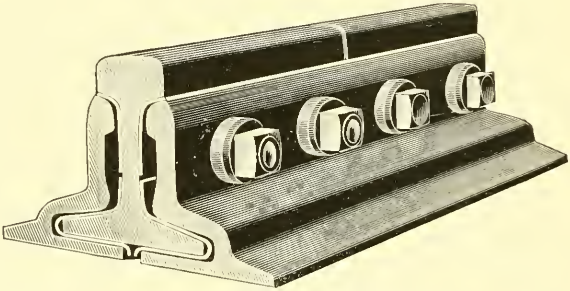
Continuous Joint



Weber Joint

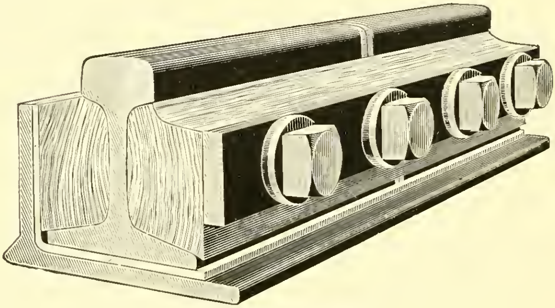


Wolhaupter Joint



Continuous Insulated Joint

Over
50,000
miles
in use



Weber Insulated Joint

Rolled
from
Best Quality
Steel

JOHN A. ROEBLING'S SONS CO.

TRENTON, N. J.

WIRE ROPE OF ALL KINDS

We manufacture and keep in stock at our works at Trenton and at warehouses, at agencies and branches in large cities wire rope made from Swedish Iron, Cast Steel, Extra Strong Cast Steel, Plough Steel and Improved Plough Steel.

We give below tables of strengths, etc., for the standard constructions of IMPROVED PLOUGH STEEL ROPE. The rope is also furnished with 6 strands of 37 wires each and with 8 strands of 19 wires each.

This rope is recommended as the best to use where extreme conditions tend to bring extraordinarily severe stresses, and is particularly well adapted to resist abrasion.

The hemp center of this rope is colored blue to distinguish it from other wire ropes.

A copy of our catalogue, giving information about other wire ropes, and wire rope fastenings, will be mailed on application.

IMPROVED PLOUGH STEEL HOISTING ROPE

Composed of 6 Strands and a Hemp Center, 19 Wires to the Strand.

Trade Number.	Diameter in inches.	Approx. circumf. in inches.	Approx. weight per foot.	Approx. strength in tons of 2000 lbs.	Proper working load in tons of 2000 lbs.	Dia. of drum or sheave in feet advised.
00	2¾	8⅝	11.95	315	63	11
0	2½	7⅞	9.85	263	53	10
1	2¼	7⅛	8	210	42	9
2	2	6¼	6.30	166	33	8
2½	1⅞	5¾	5.55	150	30	8
3	1¾	5½	4.85	133	27	7
4	1⅝	5	4.15	110	22	6½
5	1½	4¾	3.55	98	20	6
5½	1⅜	4¼	3	84	17	5½
6	1¼	4	2.45	69	14	5
7	1⅛	3½	2	56	11	4½
8	1	3	1.58	45	9	4
9	⅞	2¾	1.20	35	7	3½
10	¾	2¼	.89	26.3	5.3	3
10¼	⅝	2	.62	19	3.8	2½
10½	9/16	1¾	.50	14.5	2.9	2¼
10¾	½	1½	.39	12.1	2.4	2
10a	7/16	1¼	.30	9.4	1.9	1¾
10b	⅜	1⅛	.22	6.75	1.35	1½
10c	5/16	1	.15	4.50	.9	1¼
10d	¼	¾	.10	3.15	.63	1

IMPROVED PLOUGH STEEL ROPE

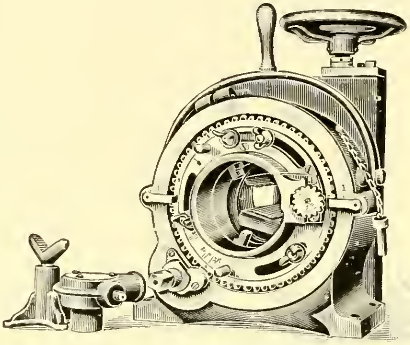
For Haulages and Transmissions. 6 Strands and a Hemp Center, 7 Wires to the Strand.

11	1½	4¾	3.55	90	18	11
12	1⅜	4¼	3	79	16	10
13	1¼	4	2.45	67	13	9
14	1⅛	3½	2	52	10	8
15	1	3	1.58	42	8.4	7
16	⅞	2¾	1.20	33	6.6	6
17	¾	2¼	.89	25	5	5
18	11/16	2⅛	.75	20	4	4¾
19	⅝	2	.62	17½	3.5	4½
20	9/16	1¾	.50	13	2.6	4
21	½	1½	.39	11	2.2	3½
22	7/16	1¼	30	7¾	1.5	3
23	⅜	1⅛	.22	6½	1.3	2½

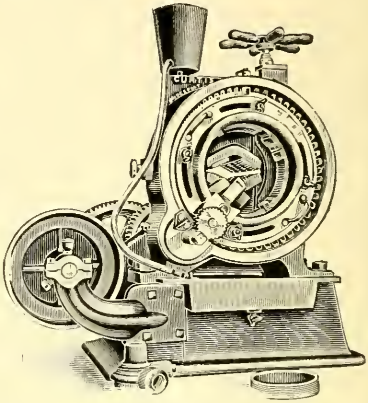
THE CURTIS & CURTIS COMPANY

93 Garden Street,
BRIDGEPORT, CONNECTICUT

PIPE CUTTING AND THREADING MACHINERY



Hand Machine



Power Machine

THE FORBES PATENT PIPE CUTTING AND THREADING MACHINE

In presenting this machine we would ask your attention to the following points:

It will save you its entire cost in a short time, in time and hard labor saved.

Our Pipe Machine is a complete tool, being all that is required to thread or cut off pipe.

It is much lighter than the old style of stock and the vise which must accompany it.

It is less expensive than the above combination.

It can be used in confined places.

It is particularly adapted to trench work.

Its dies can be sharpened by grinding without first drawing temper.

They draw back out of the way when the thread is cut, yet always cut standard sizes, and are adjustable to any variation of the fittings.

The shell can be adjusted to take up wear of gear.

Its dies are less expensive than solid dies, and last much longer.

Any one die of a set can be replaced when lost or worn out without replacing the entire set.

Its parts are interchangeable and can be duplicated when worn out, at a small cost.

MOTOR DRIVEN TYPE

This machine is equipped with a specially designed Die head which does away with all thumb screws for adjusting the dies, which are now clamped with one movement of a lever; it has self-centering vise.

BASE. Mounted on cabinet base with a motor for any current desired concealed within, and direct connected through triple compound cut spur gears on machine.

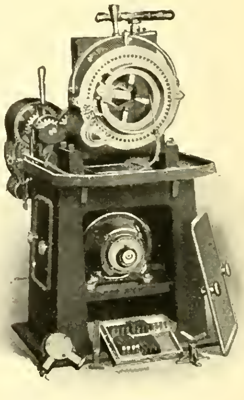
STRAINER. In center of the pan is located a strainer to seperate the oil from the chips. It is thus drained, and can be used over again until unfit for use.

PUMP. Driven by gears. It is out of the way of the operator, and direct connected. No belts to annoy you.

GEARS. All are machine cut and entirely protected from chips or accidents.

MOTOR. Any current desired concealed in cabinet base, thus protected from oil or dirt, or breakage resulting from handling of long and heavy lengths of pipe and fittings.

Complete Catalog on Request



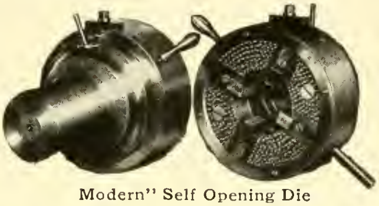
Motor Driven Machine

MODERN TOOL COMPANY

ERIE, PA., U. S. A.

**SELF-OPENING DIE HEADS, ADJUSTABLE SOLID DIES, TAP AND DIE HOLDERS
CHASER GRINDERS, FRICTION AND POSITIVE DRIVE MAGIC CHUCKS
TAPPING ATTACHMENTS AND MODERN GRINDING MACHINES
MAKERS OF SPECIAL TOOLS AND FIXTURES**

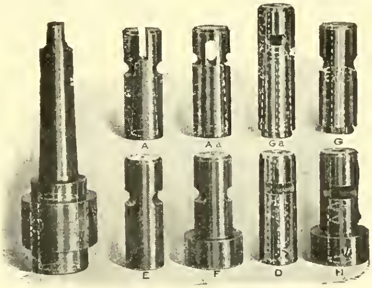
"MODERN" SELF OPENING DIES


Modern" Self Opening Die

The advantages of the "Modern" Die are many. The Die opens automatically when the thread is cut. No reversing of the machine. The return is 2½ to 1. No danger of injuring either the thread or Die. 50% to 80% in time and wear to belts and countershaft is saved. The "Modern" is the one Die having a steel cam to hold Chasers in place directly over point of duty, making it impossible for Chasers to bell at the mouth and preventing irregular or taper thread. When a large amount of stock is to be removed or precision required, a roughing and finishing attachment will be furnished.

"Modern" Chasers are all cut on a hob and are made either of carbon or high speed steel.

"MAGIC" CHUCK EQUIPMENT

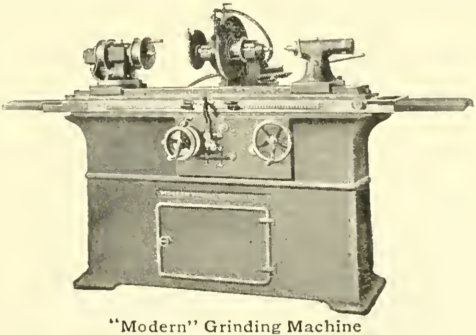


Magic" Chuck and Collets

For the rapid changing of tools in drill press, lathe, screw machine, etc., without stopping the machine, practically converting a single spindle machine into a multiple spindle one, with as many tools as you may have operations. Try it and save labor cost.

"MODERN" GRINDING MACHINES

Much unnecessary weight is eliminated and perfect rigidity and freedom from vibration secured by the scientific distribution of material in "Modern" Grinding Machines. Generous bearings for all moving parts reduces the possibility of wearing and prevents absolutely all chatter. Centralization of working parts secures perfect transmission of power to the working point. Accessibility of the working parts for care and attention by the operator makes minimum loss of use, cost of up-keep and depreciation. Improved operative features insure large production and precision work.


"Modern" Grinding Machine

ALL "MODERN" TOOLS GUARANTEED TO BE SATISFACTORY TO THE USER

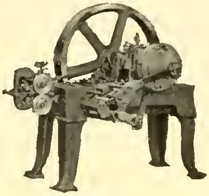
Complete information concerning products will be mailed interested parties upon request.

THE WATERBURY FARREL FOUNDRY AND MACHINE CO.

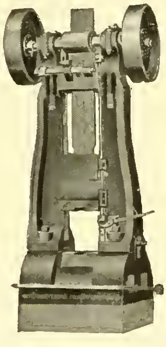
WATERBURY CONNECTICUT

MANUFACTURERS OF STANDARD AND SPECIAL MACHINERY
FOR ALL PURPOSES

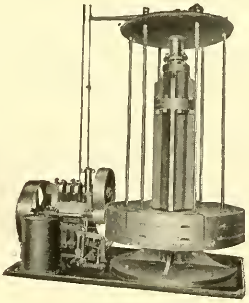
The range of machinery manufactured by this company is so great that it is impossible in this brief space to give more than a partial list of its products. Catalogs and complete information concerning any of the machines listed below or estimates and plans for **SPECIAL MACHINERY** furnished on request.



Solid Die Double Stroke Header—One Cycle



Automatic Forging Drop—Patented



Pump and Accumulator Valve Control—Constant Pressure

RIVET, BOLT AND NUT MACHINERY.

Single Stroke Heading Machines, Double Stroke Heading Machines, Triple-Stroke Heading Machines, Reheading Machines and Attachments, Special Headers (Wagon Spoke, etc.), Reciprocating Thread Rolling Machines, Automatic Nut Blank Machines, Bolt Trimming Presses, Screw Slotters, Bifurcators, etc.

BUTT AND HINGE MACHINERY.

Joint Rolling Machines, Joint Broaching Machines, Pin Driving Machines, Pin Spinning Machines.

CARTRIDGE MACHINERY

For Metallic Cartridge Cases, Friction Dial Redrawing Presses, Ratchet Dial Redrawing Presses, Shell End Trimming Lathes, Heading Machinery and Attachments, Tapering and Reducing Presses, Head Trimming Lathes.
For Primers and Primer Charging, For Bullets and Bullet Jackets.
For Loading Metallic Cases, etc.
For Paper Shot Shells.
For Cases for Rapid Fire Guns.

DROP PRESSES AND DROP HAMMERS.

Belt Lift Drop Hammers, Automatic Board Lift Drops.

FOOT AND SCREW PRESSES.

Kick Lever Foot Presses, Compound Lever Foot Presses, Screw Presses, Arch and Solid Back.

MACHINERY FOR RODS AND TUBES.

Knuckle Joint Tube Pointers, Cut-Off Saws for Rods and Tubes, Chain Draw Benches, Brazed Tube Forming Machines, Wire Thrashing Barrels, Bull Blocks.

HYDRAULIC MACHINERY.

Embossing Presses for General Use, Medal Embossing Press, Cartridge Case Heading Press, Wide Spread Embossing Presses, Presses for Machine Shop Use, Hydraulic Caking Press, Steam Plate Presses, Cupel Button Press, Testing Machines for Cast Iron Pipe, Hydraulic Drawing Presses, Horizontal Push Benches for Tubing, Draw Benches for Seamless Tubes, Hydraulic Accumulators, Accumulators and Pumps Mounted Together, Geared Triplex Pumps, Compound Pumps, Double Duplex Power Pumps, Special Hydraulic Machines and Valves.

KNUCKLE JOINT PRESSES.

Standard K-J Presses, Long Stroke K-J Presses, K-J Press Feeds and Attachments, Mint Type K-J Coining Press, Horizontal Presses, Solid Back Presses, Special Presses.

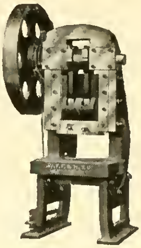
SPECIAL LATHES.

Hand Edging Lathes, Knurling Lathes, Trimming Lathes, Trimming and Forming Lathes, Screw Cap Threading Machines, Hand Feed, Semi-Automatic Screw Cap Threaders.

THE WATERBURY FARREL FOUNDRY & MACHINE CO.

SINGLE ACTING OPEN BACK PRESSES.

Plain Presses, Series A, B, C, D, E, Press Clutches, Adjustable Incline Legs, Motor Driven Presses, Geared Open Back Presses, Double Connection Presses, Presses for Trimming Drop Forgings, The Finger Motion Feed, Various Lifting and Knockout Motions, Roll Feeding Attachments, Friction Dial Feeds, Ratchet Dial Feeds, Safety Clutch Ratchet Dial Presses, Adjustable Bed and Horn Presses, Rack and Pinion Drawing Presses, Multiple Plunger Presses.



Double Connection Open Back Press

SINGLE ACTING PILLAR PRESSES.

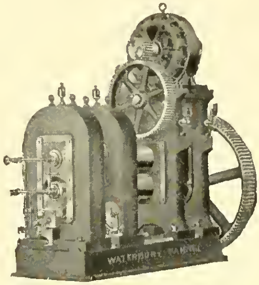
Straight Sided Pillar Presses, Arch Presses, Inclined Upright Pillar Presses, Double Connection Presses, Four Way Pillar Press, Presses for Lock Manufacturers, Arch Geared Drawing Presses, Side Shear Presses for Drop Forged Work, Pillar Presses for Sub-Press Dies, Ratchet Dial Feeds, Single and Double Ratchet Roll Feeds.

DOUBLE ACTING POWER PRESSES.

Open Back Crank Presses, Pillar Crank Presses. Feeding Attachments for D.A. Crank Presses, Open Back Cam Presses, Lifting and Knockout Motions, Pillar Cam Presses, Special Double Acting Presses.

ROLLING MILLS.

Standard Mills for Brass and Copper Sheets, Belt Driven Mills for Sheet Work, Portable Mills for Sheets, Motor Driven Mills for Mint Service, Tin Foil Rolling Mills, Small Mills for Sheet Work, Cross Rolling Mills, Rod Rolling Mills—Two and Three High, Grading Mills for Spoon Blanks, etc., Wire Flattening Mills.



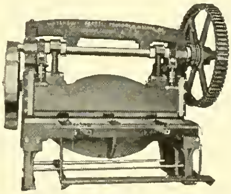
Mint Type Water Cooled Heavy Portable Rolling Mill

SHEARS AND SLITTERS.

Squaring Shears, Open Back Type, Open Back and Pillar Presses with Shearing Fixtures, Solid Back Shear Presses. Alligator or Lever Shears, Single Slitters, Slitters with Circle Cutting Attachments, Gang Slitters and Trimmers for Sheet Metal.

FINISHING MACHINERY FOR SHEET METAL.

Sheet Metal Saws, Single and Gang.
Sheet Metal Scraping or Overhauling Machines.
Sheet Metal Drying-out Machines.
Sheet Metal Straighteners
  with Spindle Drive,
  without Spindle Drive.
Sheet Metal Winders.
Sheet Metal Coilers.
Pan Pullers and Capstans.
Scrap Cabbaging Machine.



Squaring Shears for Sheet Metal

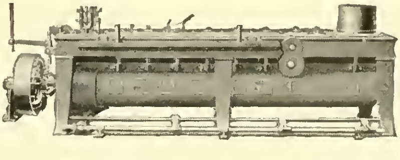
MUFFLES AND FURNACES.

Annealing Muffles.
Case Hardening Furnaces.
Tube Brazing Furnace.
"W. N. BEST" Oil Fuel Furnaces.

WATERBURY MACHINE COMPANY MACHINERY:

WIRE DRAWING MACHINES.

Continuous Type Drawing Machines.
Single Block Rod Drawing Machines.
Spooling Machinery.
Swaging Machines for Rods and Tubes.
Eyelet Machines.
Gang Slitting Machines.
Burnishing Machinery for Spoons, etc.
Cut and Carry Press.
Multiple-plunger Presses.



Upright Roll Wire Drawing Machine—Patented

HALCOMB STEEL COMPANY

SYRACUSE, N. Y.

BRANCHES, AGENCIES AND STOCKS:

Halcomb Steel Co., Syracuse, N. Y.
Halcomb Steel Co., Cleveland, O.
Halcomb Steel Co., Philadelphia, Pa.
Halcomb Steel Co., Chicago, Ill.
Hawkridge Bros. Co., Agents, Boston, Mass.

HIGH SPEED STEEL, TOOL STEEL, SHEET STEEL, DRILL RODS, FINE WIRE, COLD DRAWN STEEL AND SPECIAL STEELS OF ALL KINDS

HALCOMB SPECIAL HIGH SPEED TOOL STEEL

This steel is unsurpassed by any product, foreign or domestic, where the most severe duty is demanded, as in heavy lathe and planer work, boring tools, turning glazed tires, alloy steel gears, flat and twisted drills. It is noted for consistent uniformity of analysis, and does not require fussy treatment.

The risk of breaking in hardening is minimized and tools cannot be ruined by over-heating. These steels are also readily annealed for machining. Cutters and fragile tools do not require a sweating heat when made from our steels. They retain an excellent cutting edge, and hence show high efficiency for both roughing and finishing work.

HALCOMB KETOS OIL HARDENING TOOL STEEL

The greatest achievement in tool steel since the discovery of high speed steel. There is a place for this steel in every shop and tool room. This steel neither expands, contracts nor warps in hardening. Safest steel ever produced from which to manufacture intricate tools, dies, cutters, etc. Think of making a twenty-two inch tap with no change in pitch after hardening! Write for special booklet on Ketos.

HALCOMB SPECIAL TOOL STEEL

This steel is made in six tempers (varying from high to low carbon), to meet all tool steel requirements.

For turning, planing, and slotting hard materials, for expensive cutters, drills, forming tools, taps, reamers, punches, dies, etc.

Particularly recommended for all kinds of tools where special endurance is sought and where great strength and toughness are required.

HALCOMB EXTRA WARRANTED TOOL STEEL

This steel is made in six tempers to meet varied requirements, and is of fine quality, suitable for many kinds of tools, including wood-working bits and knives, cold chisels, drills, mining drills, granite tools, lathe and planer tools, cutters, taps, reamers, dies, shear blades, punches, etc. An excellent steel for general use.

OTHER TOOL STEELS

Other well-known brands of tool steels manufactured by this company are:

"Air Hardening Tool Steel"
"Double Extra Tool Steel"
"Peerless Tool Steel"
"Double Special Tool Steel"
"Extra Special Tool Steel"
"Standard Tool Steel"

Catalogues on request

HALCOMB STEEL COMPANY

PIONEER AMERICAN MAKERS OF ELECTRIC FURNACE ALLOY STEELS

These steels are chemically pure and free from sulphur, phosphorus and gases. They are completely deoxidized, thoroughly melted, homogeneous, and free from segregation, seams, and surface defects. They are easy to machine and respond with certainty to any definite heat treatment. They are very readily drop forged, and are not apt to be injured by over-heating.

Electric Furnace alloy steels have wide hardening ranges, so that uniform results can be had in plants not equipped with the latest devices for controlling temperatures. In resistance to fatigue they stand from 50% to 100% better than corresponding compositions made by other processes.

We make a specialty of Alloy Spring Steels, which are characterized by greater strength and fatigue values than ordinary spring steels. They thus permit of greater fibre stresses without sacrificing present factors of safety, and consequently make possible substantial reductions in weight.

These alloy steels are especially well suited for the construction of machine tool and automobile parts.

ELECTRIC NICKEL STEEL

Nickel Steel is perhaps the most generally useful of the alloys. In various conditions of thermal treatment, it displays wonderfully good qualities, and is well suited to the production of structural parts. It case-hardens well, and in machining qualities is superior to the usual alloy steels.

CHROME VANADIUM STEELS

The manufacture of genuine Crucible or Electric Chrome Vanadium Steels constitutes the highest attainment of the steel makers' art. By the proper blending of these alloying metals and adjustment of the carbon, we not only obtain every static property that can be obtained from Nickel, Chrome Nickel, Silico-Manganese or other alloys, but also obtain wonderfully enhanced dynamic or antifatigue qualities.

In general, when a better material than Nickel Steel is needed, we unreservedly commend our Chrome Vanadium Steels.

OTHER ELECTRIC FURNACE ALLOY STEELS

The Halcomb Steel Company also manufacture Chrome-Nickel Steel, Chrome-Silicon Steel, Silico-Manganese Steel, and other alloys to meet special requirements.

COLD DRAWN AND COLD ROLLED STEEL

We are prepared to furnish cold drawn steel from .007 in. to 3 in. diameter in rounds and corresponding sizes in squares, flats and special shapes, exact to size.

HEAT TREATING AND ANNEALING

We are prepared to furnish any of our products, either tool or alloy steels, hammered or rolled, in the form of billets, bars or forgings, and unannealed, annealed or oil-tempered. Our heat-treating facilities are unexcelled, thoroughly modern and up-to-date in every way and under competent technical supervision. We act in an advisory capacity for our customers in reference to all matters pertaining to heat-treatment and heat-treating equipment, pyrometers etc.

THE PETROLEUM IRON WORKS CO.

SHARON, PA.
NEW YORK ST. LOUIS HOUSTON, TEXAS

FABRICATORS AND ERECTORS OF EVERY VARIETY OF LIGHT AND HEAVY STEEL PLATE CONSTRUCTION.

TANKAGE FOR ALL PURPOSES LARGE OR SMALL; OIL REFINERY EQUIPMENT, STAND PIPES, WATER TOWERS, SMOKE STACKS, PENSTOCKS, RIVETED STEEL PIPE, BLAST FURNACES, HOT METAL LADLES, BOILERS, ANNEALING BOXES, "LEMAN" COUNTER CURRENT CONDENSERS, "GEM" FUEL OIL BURNERS, "WASHINGTON" AUTOMATIC OIL AND GAS SEPARATORS, PORTABLE RECEIVING TANKS, CAR TANKS ETC.

The Petroleum Iron Works Company is located on a property of forty acres, situated about three miles south of Sharon, Pa.

Our railroad facilities here are excellent, as the works have direct connections with the New York Central, the Erie and the Pennsylvania Railway Systems. Our trackage for receiving and shipping inbound and outbound freight is more than a mile in length, thus affording ample space for car storage and ideal facilities for making shipments. Car shortages and delays occurring where there is but one railroad connection are practically unknown in this district. We, therefore, feel sure the trade will fully appreciate this condition, as it enables us to guarantee our promises of delivery to points in every direction.

Our present plant consists of a substantial steel structure, fully equipped with modern machinery, tools and appliances, which insure accurate and rapid production. We are now in position to give our customers better satisfaction and more prompt service than ever before. Superior manufacturing facilities and careful shop inspection will continue to maintain our long established reputation for high class work.

It is difficult to prepare a catalogue that will adequately describe and illustrate all the classes of sheet metal structures and apparatus that we are in position to furnish and erect. The illustrations presented are shown merely as types of our various lines of work, among which we might enumerate the following:

Oil Storage Tanks (large and small)
Acid Storage Tanks
Water Tanks
Water Softener Tanks
Molasses Tanks
Turpentine Storage Tanks
Grain Tanks
Tar Tanks
Hydro-Pneumatic Tanks
Pressure Tanks
Filter Tanks
Car Tanks
Portable Receiving Tanks
Railroad Water Service Tanks
Oil Refineries (complete)
"Leman" Counter Current Condensers
"Washington" Automatic Oil and Gas Separators
"Gem" Fuel Oil Burners
Riveted Steel Pipe
Flumes
Penstocks
Blast Furnaces (complete)
Converters
Hot Metal Ladles
O. H. Furnaces
Pulp Digesters
Galvanizing Kettles
Creosoting Cylinders
Condenser Boxes
Coal Bins
Steam Separators
Air Receivers
Water Towers
Stand Pipes
Smoke Stacks (Self-Supporting and Guyed)
Breechings, etc., etc.

Frequently special problems arise, and in such cases we are glad to offer the services of our Engineering Department. In order to assure prompt replies to inquiries we respectfully request complete detail information, including specifications and blue prints when possible. We hope by prompt and careful attention to our customers' inquiries to be favored with at least a portion of your valued orders.

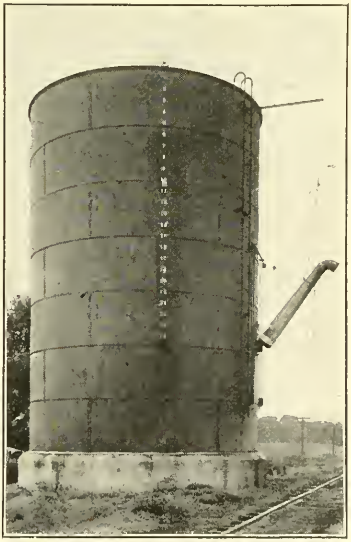
We issue no discount sheet owing to the constant fluctuations in prices, and for the reason that practically all of our products are built to order.

THE PETROLEUM IRON WORKS CO.

OIL REFINERIES—COMPLETE

10′ x 30′ Single, Double, and Triple Compartment Cylindrical Horizontal Oil Storage Tanks ready for shipment.

150 000 Gallon Water Tower,
Yonkers, N. Y
(Height over all 184′)



R. R. Water Service Tank.
Erected East Waco, Texas, for the
'Cotton Belt."

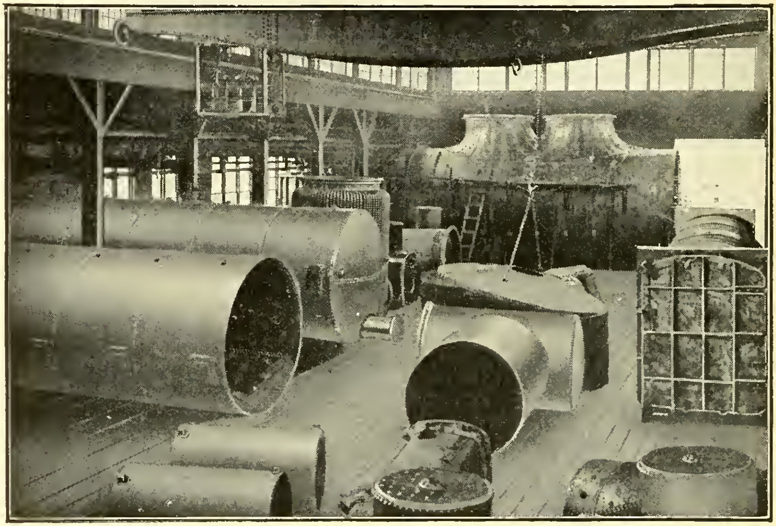
STRUTHERS-WELLS COMPANY

Established 1851

WARREN, PENNSYLVANIA

N Y. Office, 50 Church St

ANYTHING IN STEEL PLATE CONSTRUCTION FOR BEET SUGAR REFINERIES PAPER MILLS, OIL REFINERIES, SOAP FACTORIES, WOOD ALCOHOL AND TURPENTINE PLANTS, TANKS (FOR STORAGE OR PRESSURE) WITH EITHER WELDED OR RIVETED SEAMS. PENSTOCKS, RIVETED PIPE FOR HYDRAULIC AND STEAM PRESSURE, EXHAUST PIPES, STEAM HEADERS, EXHAUST HEATERS, BRICK HARDENING CYLINDERS, GALVANIZING POTS, RETORTS, STILLS, AGITATORS, STEAM PANS, AND JACKETED KETTLES



View of one corner of Erecting Floor

We will contract to furnish specially designed work in steel plate from customers' plans and specifications, either completely built up in the shop or assembled, knocked down and shipped in sections as may be called for.

Our equipment and experience enable us to handle both intricate and simple work with equal ease and dispatch. Our workmanship will pass the most rigid inspection.

We maintain a fully equipped estimating department at our shops and also at our New York Office. This enables us to furnish prices promptly.

If you want a specially designed piece of work, send us your drawings and specifications,—we have probably built it before, or at least something very similar to it.

Smoke breechings, stacks and air flues for modern buildings are right in our line.

THE AMERICAN BRASS COMPANY
THE COE BRASS BRANCH

ANSONIA, CONN

EXTRUDED METALS

The word "extrusion" accurately describes the operation by which the various sections are formed.

A billet of brass is first cast of a convenient size and suitable composition for the purpose intended. This billet is re-heated until it is of a plastic consistency, and then, by means of a small crane, it is placed within a very strong horizontal cylinder or "container," at the front end of which is the die. Upon hydraulic pressure being applied at the rear end of the container the plastic metal is forced or squirted through the die, issuing therefrom in a long bar having a cross-section corresponding to the hole pierced in the die.

The very high pressure (oftentimes as high as 60,000 pounds to the square inch) to which the semi-plastic metal is thus subjected gives it increased density and renders it perfectly homogenous and free from possible casting defects. The bars produced by this process have a greater strength and tenacity than those made by rolling or other cold working methods, and for special purposes alloys are made having the requisite strength and elongation for work demanding the strength of good quality steel. It is also obvious that sections which cannot possibly be rolled or drawn can be made by the Extrusion Process with great accuracy.

In addition to bars or rods of irregular cross section, all stock sizes of round, hexagon, square, rectangular, half-round, etc., are produced suitable for forging and all engineering purposes. Alloys used for this purpose are Nickel Bronze, Muntz Metal, and other special bronzes suitable for forging. Free cutting brass rods are made also for manufacturing purposes. The alloys used for making angles, channels, T-bars and special shapes for marine work have a high tensile strength and are particularly non-corrosive in their qualities.

A considerable use that has been found for this metal is in the form of mouldings for architectural work. It is well adapted for use in large stores and office buildings, railroad stations, residences, etc., and can be oxidized to give it any color desired.

Extruded mouldings are also supplied for use in the construction of passenger and sleeping cars, as the metal will take a high finish, is durable, and does not rust out or corrode in service. It is also largely used for step treads, step nosings, platform bindings, hinges, and door stops, having taken the place of brass castings for these purposes. In fact extruded shapes made in a free drilling and free milling stock have superseded castings for many purposes. The metal being perfectly smooth and accurate requires little if any machining, and is utilized in a great variety of manufacturing lines, small pieces being sawed or milled from special shape extruded brass bars to take the place of machined castings. This affords an efficient and economical means for making small, intricate parts such as cams, dogs, pinion wheels, and various other parts that are required in the manufacture of locks, typewriters, telephone and telegraph instruments, switchboards and other electrical apparatus.

The dimensions of the finished bars are limited by the weight of the billets used, and range in weight from 100 to 140 pounds. We are able to produce special shape bars or rods ranging from light sections of about 3-8 in. diameter and weighing a fraction of a pound per foot, to heavy sections 5 or 6 inches in width and weighing many pounds per foot. It will thus be understood that light sections may be had in long lengths and heavy angles, etc., in lengths of from 12 to 18 feet.

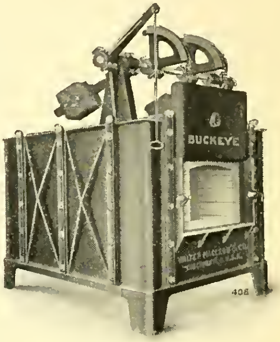
WALTER MACLEOD & COMPANY

CINCINNATI, OHIO, U. S. A.

BUCKEYE METALLURGICAL FURNACES FOR FORGING, WELDING, ANNEALING, HARDENING, TEMPERING, HEAT-TREATING, CASE-HARDENING ETC. RIVET FORGES, BLOW TORCHES, BRAZING TORCHES, OIL BURNERS, STEEL FAN PRESSURE BLOWERS, POSITIVE PRESSURE BLOWERS, OIL PUMPS, OXY-ACETYLENE APPARATUS FOR WELDING AND CUTTING

BUCKEYE METALLURGICAL FURNACES

DESIGN.—Designs of the furnaces vary with the type according to the nature of the work to be done. For annealing, hardening, case-hardening and tempering or similar operations requiring very accurate temperatures, a semi-muffler type of furnace is used. In this furnace the material is heated in a separate chamber from that in which combustion takes place, the combustion chamber occupying a position under the furnace, its construction permitting the proper expansion and distribution of the gases of combustion which are carried to the arch of the furnace and reverberated to the hearth heating the material in the most protected manner from oxidation. In types designed for welding and high temperature operations, the flame is introduced directly beneath the arch, the latter being constructed to carry the flame upwards, allowing proper combustion and distribution before deflecting upon the hearth.



Buckeye Heat-treating Furnace

CONSTRUCTION.—Cast iron plates of suitable thickness and construction to withstand the duty they are to perform, held in position by buck stays and tie rods, are used to support the refractory material, the best obtainable quality for the purpose only being used.

BUCKEYE SAND BLAST

Buckeye Sand Blast
Type A

Quantity of Air and Air Pressure Required :

A Common Pressure is from 60 to 80 pounds. It is much better to use, say 70 pounds pressure than 25 pounds such as is used in some other machines, as the latter, to carry the same sand and air, would require larger size of hose and fittings and be much more bulky and heavy to handle.

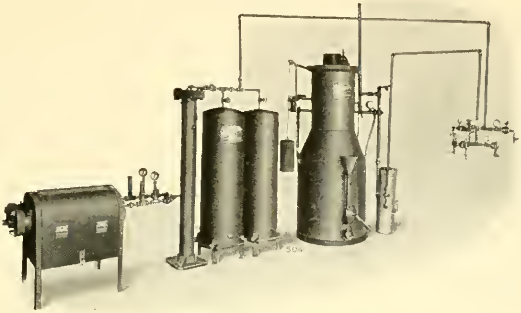
Nozzle $\frac{3}{16}$ in. diam. requires 50 cb. ft. per min.
" $\frac{3}{8}$ " " " 85 " " " "
" $\frac{1}{2}$ " " " 125 " " " "

SURFACE CLEANED PER MINUTE

This would depend on the operator, the character of work and the favorable position of same. It is possible under very favorable circumstances to clean one square yard or nine square feet in one minute, but this would not be sustained. An average from one to three square feet per minute ought to be obtained unless the work is complicated.

WALTER MACLEOD & COMPANY

THE BUCKEYE OXY ACETYLENE OUTFIT



Buckeye Oxy Acetylene Outfit Complete

The illustration shows a complete installation, all connected and ready for operation, except that the Acetylene Generator must be placed some distance away, and should be placed according to Insurance Regulations in a room by itself, with the proper vents leading outside to carry away any relief pressures. The number of Oxygen Receivers also varies with the size of plane, the smaller sizes having one, whereas the largest size has four. The Oxygen Generator if desired can be placed near where the work is being done as very little attention is necessary, charges only requiring to be made when receiver is depleted. Most other plants you buy would leave you dependent for either your Oxygen or Acetylene Gas Supply on sending tanks to and fro, and when you needed gas most, that is the time you would be shy. When you buy the Buckeye Plant you make all your own gases.

WELDING

The operation of welding is a very simple one, but skill is necessary to produce perfect work and a beginner must not expect to do as good work as an operator who has had considerable experience; it is not, however, difficult to learn and, as in many other processes, experience is the best teacher.

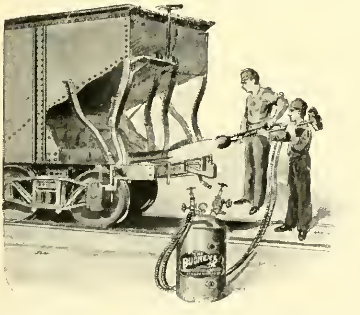
Where the distance prohibits a visit, we can help and instruct the operator very much if he follows our instructions.

CUTTING

Steel or Iron (not Cast Iron) can readily be cut by the Oxy Acetylene process. The experiment of heating a piece of iron, then burning it by plunging same in a tube of oxygen is a very old laboratory experiment, yet this is what practically occurs with our cutting torch; instead of plunging the piece into oxygen, a jet of oxygen is forced into the metal already heated by the Combination jet of acetylene and oxygen. The hot metal is instantly oxidized and the pressure of the gas blows away the oxide and the molten metal.

THE BUCKEYE HEATER

FOUNDRY APPLICATIONS.—The Buckeye Heater is of value in a foundry for Skin Drying Molds and Cores, Drying out Metal Ladles, Firing the Coke in a Cupola, Burning on Broken Castings, etc. It saves expense by saving time and labor.



Repairing Steel Car with Buckeye Heater

THE BUCKEYE HEATER FOR RAILROADS

In railroad work the Buckeye Heater is valuable for repairing Steel Cars, Bent Engine Frames, Flanging, Boiler Repairs, Pipe Bending, etc.

It is invaluable for heating sagged ends, crown sheets, laying on patches, laying up laps around water legs and openings, and for many other operations. The flame is directed at any desired angle and only on the part to be treated.

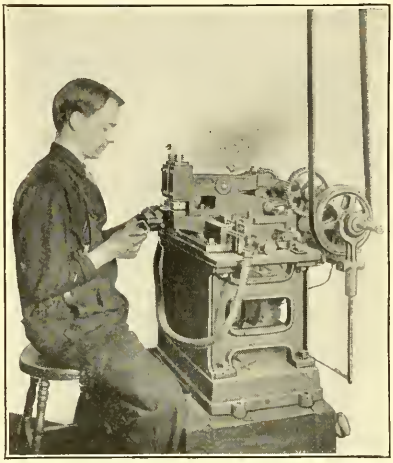
THOMSON ELECTRIC WELDING CO.

LYNN, MASS.

A COMPLETE LINE OF ELECTRIC WELDERS FOR BUTT, SPOT AND SPECIAL WELDING, OPERATED BY HAND, FOOT, SEMI-AUTOMATIC AND AUTOMATIC CONTROL

SPECIAL WELDERS A SPECIALTY

TYPE 7A AUTOMATIC



For welding rings, hoops, buckles, etc. Machine-made in various forms, making 10-20 welds per minute

COST, TIME, POWER

Iron-Steel Ro.	Area.	Horse-Power	K.W.	Seconds	Approx. K.W. hrs. 1000 Welds
¼	.05	5	4	2	2
⅜	.11	8	6	3	5
½	.20	12	9	6	15
⅝	.31	16	12	10	30
¾	.44	20	15	15	65
⅞	.60	24	18	18	90
1	.79	26	20	20	113
1⅛	.99	33	25	24	167
1¼	1.23	40	30	33	275
1½	1.77	50	38	40	422
1¾	2.41	64	48	48	640
2	3.14	80	60	60	1000

COST

Multiply the K.W. hours used by the number of cents your current costs per K.W. hour, and you get the current cost per 1000 welds for sizes shown on above table.

TIME

The time of welding runs from 1-5 second in small wire to 60 seconds in sections such as 3 square inches.

POWER

The power varies from 1 K.W. for 1-5 second to 60 K.W. for 60 seconds. Within certain limits the GREATER THE POWER, THE LESS THE TIME; and VICE VERSA. DIRECT CURRENT cannot be used, the welder being operated upon a single-phase of any constant potential ALTERNATING current, from 110 to 500 volts.

SPECIFICATIONS OF STANDARD TYPES

TYPE.	Approx. Weight	DESCRIPTION	DIMENSIONS			Max. K.W. Trans. Capacity	Approx. Equivalent Horse-Power	WELDING CAPACITY				Approx. Time in Sec. for Welds	
			Inches					Min. Inches		Max. Inches			
	Lbs.		Length	Width	Height			Ro	□″	Ro	⊔″	Min.	Max.
1AA	90	Semi-Automatic	16	11	13	1.5	2	No. 23	wire	No. 15	.003		1
2A	150	Semi-Automatic	15	12	15	3.	4	No. 16	.003	¼	.05	1	2
2AA	140	Semi-Automatic	13	14	15	3.	4	No. 16	.003	No. 6	.03	1	2
2A	200	Automatic	16	24	17	3.	4	No. 16	.003	No. 6	.03	1	2
3A	500	Automatic	29	23	44	4.5	6	No. 10	.02	¼	.05	1	2
5A	525	Semi-Automatic	27	15	18	7.5	10	No. 8	.02	⅜	.11	1	4
5A	525	Hand	27	15	18	7.5	10	¼	05	⅝	.30	2	10
5AA	550	Semi-Automatic	27	15	20	7.5	10	No. 6	.03	¼	.05	1	2
7A	800	Automatic	31	24	36	6.	8	No. 8	.02	¼	.05	1	3
10A	900	Hand	32	16	32	15.	20	⅜	.11	¾	.44	4	15
10A	1000	T Welder	33	21	28	10.	13	3/16	.03	⅝	.30	2	10
20A	2500	Hand	48	30	36	30.	40	⅜	.11	1¼	1.23	4	33
20A	1500	T Welder	41	20	30	20.	27	¼	.05	¾	.44	2	15
40A	7000	Hand	90	36	38	60.	80	¾	.44	2	3 14	15	60

DAVIS-BOURNONVILLE CO.

90 WEST ST., NEW YORK 515 LAFLIN ST., CHICAGO

OXY-ACETYLENE WELDING AND CUTTING APPARATUS

FOR REPAIRING, MANUFACTURING, METAL CONSTRUCTION AND WRECKING.

With the Oxy-Acetylene Welding and Cutting Process, iron, steel, cast iron, aluminum, brass, copper, platinum, and other metals can be so perfectly united that when smoothed the joint is not discernible; different metals may be welded together, as steel, brass, copper and aluminum; steel and iron (except cast iron) can be cut to the thickness of several inches with a narrow, smooth cut, with no material injury by oxidation.

The process, with efficient equipment, is especially valuable in repair work for welding broken castings and building up worn parts; in the foundry for reclaiming defective castings coming from the mold with blow-holes, sand holes, cold shuts, lugs off, etc., and for uniting parts difficult of casting whole; in manufacturing, for uniting metal parts, securing homogeneity and rigidity, for welding parts together instead of pressing difficult shapes, and for effecting general cost-reduction by time saving and simplifying former methods; for cutting steel, in manufacturing and repair work, and wrecking structural iron work and scrapping.

It is a "putting on" process, adding new metal homogeneously.

The Davis-Bournonville system provides both efficiency and economy of operation in Oxy-Acetylene Welding and Cutting—provable by practical demonstration. The distinctive features of the system are (1) both gases, oxygen and acetylene, are used under independent and readily controllable pressure, constituting the High Pressure Process, as distinguished from the Low Pressure Process, in which the acetylene is brought into use by the principle of induction with the oxygen pressure; (2) a fixed proportion of gases which has proven efficient in producing the neutral flame, and which is about 25% less oxygen than used in the low pressure process; (3) a light, compact, dependable torch, or blow-pipe, receiving both gases under pressure in the required proportion, and effecting a perfect mixture which produces the (4) neutral flame essential to efficient welding of both light and heavy material, without oxidization by an excess of oxygen in the flame, nor carbureting with an excess of acetylene; (5) The Davis Acetylene Pressure Generator, the result of many years experience in acetylene generation, generating acetylene up to a pressure of 15 lbs.; the only Pressure Generator with automatic feed and independent power, using lump carbide—lump carbide generating ½ cu. ft. more acetylene gas to the pound of carbide than the small sizes. This generator meets the requirements of the National Board of Fire Underwriters in all particulars; (6) complete equipment, stationary and portable welding and cutting apparatus, acetylene and oxygen generating and compressing plants for railroad shops, navy plants and large industries; (7) Results—the results in both light and the very heaviest welding effected with Davis-Bournonville Apparatus, have been the inducement in the final analysis which has placed Davis-Bournonville Equipment with U. S. Navy Yards, Railroad Shops, and the largest industries in the United States in the iron and steel and machine trades.

OXYGEN FOR WELDING AND CUTTING

is supplied for Oxy-Acetylene Welding in cylinders of 100 cu. ft. capacity, under pressure. The Davis Oxygen Company has generating and compressing plants for charging cylinders at Harrison and Jersey City, N. J., Cleveland, Ohio, and Chicago, Ill. The Davis-Bournonville Company is exclusive sales agent for the Davis Oxygen Company and for the "Lavoisite" system of oxygen generation. The "Lavoisite" system is provided for process operators at a distance from generating and compression plants, or who, for other reasons, desire their own generating plant, producing oxygen under pressure at the lowest cost for Chemical Oxygen.

Full information and illustrations, with location of demonstration plants in various states, may be had on request from either New York or Chicago Office.

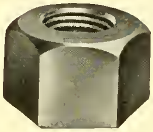
THE MILTON MANUFACTURING COMPANY

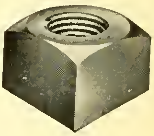
MILTON, PENNA.

MANUFACTURERS OF STRICTLY HIGH GRADE NUTS

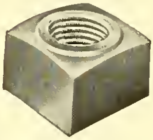
Cold Punched Chamfered Square or Hexagon—Plain Square or Hexagon—Hot Pressed Square or Hexagon (Blank with drilled holes or tapped to Pratt & Whitney Standard)—Semi-finished—Finished, Finished Case Hardened, Slotted and Castle. Nuts made from either Iron or Steel to Standard dimensions or blue print specifications.

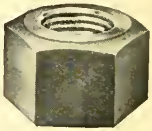
From the purchase of the raw materials until the finished product is ready for shipment, the manufacture of "Milton" Nuts is under the constant supervision of men who know, theoretically as well as practically, thus assuring the purchaser of receiving an absolutely uniform Nut, rendering a superlative degree of Efficiency at all times.



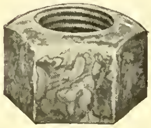


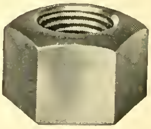
Many builders of the most intricate machinery are specifying "Milton" Nuts exclusively, owing to their accuracy, which admits of rigid construction and prevents vibration, at the same time adding mechanical refinement to their machines.





We have faith that, knowing our materials and their uses by technical and practical knowledge, we can meet in our line the highest scientific requirements.





AUTOMATIC WEIGHING MACHINE COMPANY

Office and Factory

134 COMMERCE ST., NEWARK, N. J., U. S. A.

Western Office: 439 Pierce Bldg., St. Louis, Mo., U. S. A.

Cable Address: AWMCO

AUTOMATIC WEIGHING, PACKING AND SEALING MACHINERY

ADAPTED TO THE USE OF MANUFACTURERS AND PACKERS OF SUGAR, COFFEE, SPICE, SNUFF, WASHING POWDER, BAKING POWDER, STARCH, SEEDS, CEREALS, GRAINS, FLOUR, WHEAT, ROLLED OATS, SALT, FERTILIZERS, COTTONSEED MEAL, LIMESTONE AND SHALE, CLINKER AND GYPSUM.

TO ENGINEERS

The best results and the highest efficiency accomplish their ends by the simplest and most direct means.

All of our machines are constructed with the idea of long life and efficiency, and an opportunity to describe them more fully than the space here allows would be appreciated.

The automatic weighing scale is now a recognized necessity in manufacturing, whether for packing packages, bags or boxes, proportioning two or more materials in a mix or checking bulk goods going from point to point; but that scale to be valuable must be capable of doing its work daily, and with precision, so if you are looking for those machines which give you the highest results, all other conditions being taken into consideration, we will have the pleasure of a more direct communication.

TO MANUFACTURERS

Our pride is to fulfil the just expectations of the purchasers of our machinery. We believe in co-operation, finding such a relationship between ourselves and our customers the most profitable.

To those who are earnestly desiring to cut down to its lowest their ultimate cost, we know we can be of inestimable service, and upon examination of the various circumstances peculiar to any given case, will submit such propositions that any buyer is able to give our proposals careful and intelligent consideration, and form a comprehensive view of what we will undertake to do.

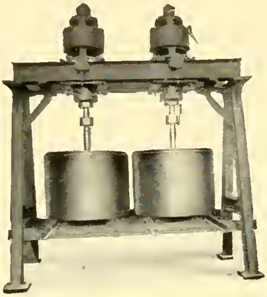
At infrequent intervals where we have found that for some reason, clearly indicated by us to our inquirers, we were persuaded the conditions would not make the use of our machinery truly profitable to the manufacturers and therefore to us, we do not fail to say so, rather than merit the displeasure of our customers by putting them to needless trouble and probable expense.

We, of course, put before anything else the fulfilling of all guarantees which are clearly stated in our proposals, and strive to do even a little better, so that when a balance is struck between us there remains something to our credit in the good opinion of our customers.

THE D'OLIER ENGINEERING CO.

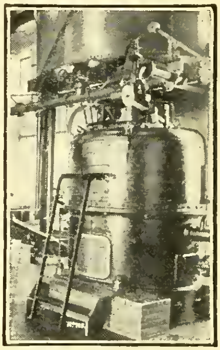
PHILADELPHIA

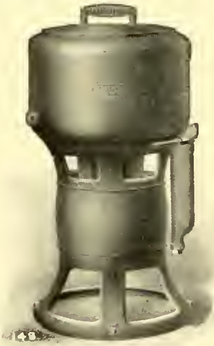
CENTRIFUGAL MACHINES FOR SUGAR, CHEMICALS, SEWAGE, OIL AND WASTE RECLAIMING, CLARIFYING AND FILTERING AND TEXTILE WORK.
BELTED, ELECTRIC MOTOR OR STEAM TURBINE DRIVEN.



STANDARD ELECTRIC CENTRIFUGALS, 2 in battery on framing, making a self-contained unit. For sugar work, chemicals, etc. A strictly high grade machine of rugged construction; capable of results vastly superior than obtained from the belted or water driven machines formerly used.

SLUDGE CENTRIFUGALS for the drying of sludge emanating from town sewage. The only successful continuously operating machine. Successfully used abroad and being now introduced in America. We are sole representatives and will be pleased to confer with and submit further data to interested engineers.





OIL AND WASTE CENTRIFUGALS are made from 10 to 20 in. for the reclaiming of oil from waste, bolts, nuts, turnings, etc. Driven by belt, steam turbine or electric motor. Special machines provided with steam jacket around bowl for most efficient separation.

CLARIFYING AND FILTERING CENTRIFUGALS:—

We are manufacturing a line of special clarifying centrifugals for the removal of all impurities, gums, fibre, pith, etc., from sugar bearing solutions, thereby yielding a greater purity of sugar. Can also be used for clearing oils, varnishes, extracts and any liquids carrying foreign material, either solid or flocculent.

We make a specialty of the design and manufacture of special centrifugal machines, especially those for extreme high speeds.

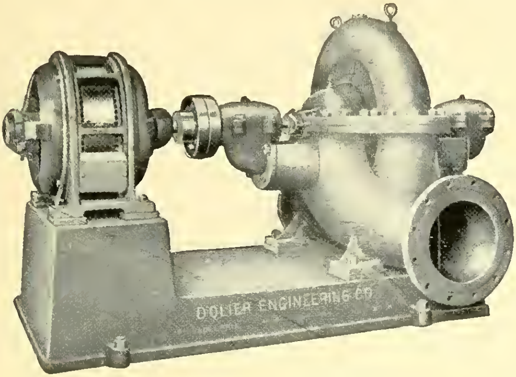
Send for Catalog.

THE D'OLIER ENGINEERING CO.

PHILADELPHIA

D'OLIER VOLUTE AND TURBINE PUMPS

FOR WATER WORKS AND IRRIGATION, FIRE SERVICE, BOILER FEED, MINE DRAINAGE, CONDENSER SUPPLY, SEWAGE, FILTRATION SYSTEMS, HYDRAULIC MINING, AND GENERAL SERVICE.

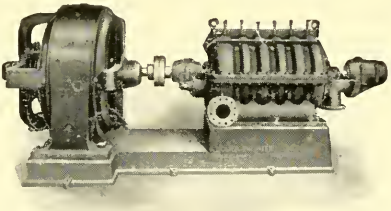


D'Olier Volute Double Suction Pump, 3000 G. P. M.—125 ft. total head.

Steam turbine and electro-motor pumps. Made with cases horizontally split, facilitating access to running parts. Impellers usually of high grade bronze. Bearings separate from stuffing boxes.

Pumps carefully designed and built for particular service required.

Complete pumping and power plants installed.



6″-6 Stage D'Olier Turbine Pump, 700 G. P. M. at 700 ft. total head.

We manufacture only a high grade, high efficiency pump, using the best grade of materials throughout. The impellers are accurately designed and carefully finished, thereby insuring maximum efficiency.

We solicit your inquiries and will be pleased to quote on receipt of information as to capacity, pressure, speed, and method of drive, with steam or electrical characteristics of driver.

Send for Catalog.

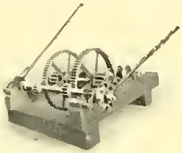
RODNEY HUNT MACHINE COMPANY

ORANGE, MASS., U. S. A.

TURBINE WATER WHEELS, FLUMES, PENSTOCKS, CANAL AND RESERVOIR
GATE APPARATUS, ROTARY, TURBINE AND CENTRIFUGAL PUMPS,
HEAVY POWER TRANSMISSION EQUIPMENTS, TEXTILE
WET FINISHING MACHINERY

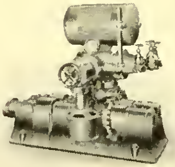
HUNT IMPROVED DRAW BAR GATE APPARATUS

This illustration shows the adaptability of improved apparatus in connection with our Hunt-McCormick Turbines when mounted on a horizontal shaft. The sliding draw bar, extending thru the packing bearing with brass bushing located in bracket casting riveted to outside of cylindrical flume, is provided with a machine cut cogged rack on outer end. A small spur gear operates the draw bar rack and a larger spur gear on the same shaft has a pin clutch on the side. The main gate shaft, extending over the clutch spur gear, operates same with small pinion spur gear so that engaging or disengaging operation of the gearing when running is readily and quickly effected by use of a pin clutch.



HOISTING AND HEAD GATE APPARATUS

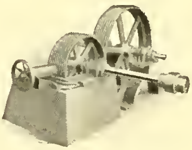
Having one of the largest assortments of both Hoisting Apparatus and Head Gate Apparatus, we are able to offer designs meeting practically every requirement both for Gates and Hoisting Mechanisms. Also Wood Bulk Head Gates, etc. See Catalog 29, Section H-G.



ROTARY FIRE PUMPS

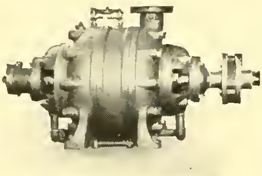
(National Standard Type A and B)

The water passages are made larger than in pumps hitherto built. In order that it may start instantly at all times, the working cams and water casings are made of *solid brass*. The shafts are very heavy, with liberal bearings. Fittings include a pressure valve, a relief gauge and cone, a priming pipe and valve, a starting valve, two to six hose valves, and a capacity plate.



POWER TRANSMISSION FRICTION GEARS

Our heavy duty Grooved Friction Gears are of substantial design throughout. The spring yoke press frames with angular split bearings ensure even distribution of pressure over the full face of both gears. Also angle of grooves gives high efficiency results. Approved and accepted by the Underwriters for fire pump service.



TURBINE AND CENTRIFUGAL PUMPS

Our Turbine Pumps are especially adapted for operating by electric motors. Proper provision for every requirement for such pumps is made in our design. Absence from vibration readily tested by balancing a coin on casing when in operation.

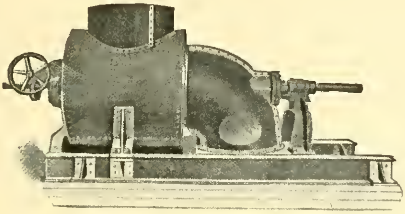
Our Centrifugal Pumps are constructed with special reference to durability and long service, and are adapted for practically every requirement.

HOLYOKE MACHINE COMPANY

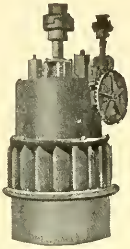
HOLYOKE, MASS.

WATER WHEELS AND GEARING

SHAFTING AND MILL WORK, PUMPS, HYDRAULIC PRESSES, PAPER AND WOOD PULP MACHINERY, ETC.



Horizontal Turbine



Vertical Turbine

WATER POWER DEVELOPMENTS

The Holyoke Machine Co. has complete engineering and manufacturing facilities for the development of water power plants of all kinds. We are prepared to furnish designs and machinery of standard or special pattern, and are always glad to bid for work in our line. The services of our engineering staff are always at the service of prospective purchasers.

We manufacture Boyden and Hercules Turbine Wheels, both vertical and horizontal, with flumes and all connections. Water Wheel Governors and Head Gates to suit all conditions and all necessary gears, shafts, pulleys, and Mill Work.

BEVEL, MITER AND SPUR GEARS

Our gears are made of Charcoal Iron of such mixture as insures maximum strength and durability, making them far superior to Gears made from ordinary Anthracite Iron. Our collection of gear patterns is one of the largest in the country, and all patterns are kept in first-class condition. We have pattern-makers constantly employed in making new gear patterns, and can usually furnish gears from special patterns to order in a short time.

PLANED GEARS. For many years we have made a specialty of Planed Gears, and with large facilities for such manufacture, we are prepared to furnish both Bevel and Spur, Angle and Mortise Gears, finished with exactness and promptness. Catalog on request.

OTHER PRODUCTS

Other manufactures of the Holyoke Machine Company include: Improved Paper Machinery and Machinery for Wood Pulp Mills, Cotton, Paper, and Husk Rolls. Chilled Iron Rolls, Machinery for Bleacheries and Dye Works, Rotary Fire Pumps, and Friction Drives, Power Pumps, Hydraulic Presses and Pump.

Special Machinery and Iron Castings of every description made to order.

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THE
JOURNAL
of
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

MARCH 1912

35 CENTS A COPY $3 A YEAR

SPRING MEETING: CLEVELAND, OHIO
MONTHLY MEETINGS: NEW YORK, MARCH 12;
BOSTON, MARCH 15

ARE YOU DOING ALL YOU CAN TO FURTHER THE AIMS OF THE SOCIETY?

This is the Industrial Age and the United States is preeminently an industrial country. The American Society of Mechanical Engineers is the society of the Industries.

Recognizing the extent to which industrial expansion has increased the scope of the mechanical engineering profession, the Society realizes its responsibility to promote the advancement of the industries. For the solution of these problems the support and coöperation of the best engineers and executives in each field are necessary.

At the meetings of the Society and in its publications every facility is had for the discussion of technical problems, the presentation of papers, researches and reports, and the free interchange of ideas. Every member receives benefit and in turn contributes from his own knowledge and experience.

The undersigned members have been charged by the Council to urge upon the membership the need of securing for this important work representative men of the highest type.

The Committee is confident that you will respond to this invitation by contributing your personal efforts and by advising the Committee regarding the conduct of its work in your vicinity.

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ISSUES OF THE JOURNAL WANTED

The Society wishes to secure copies of the following issues of The Journal: Mid-November 1906, Mid-October 1907, May 1908, October 1909, October 1910, January 1911. These will be purchased from members at 25 cents a copy.

SPRING MEETING

The Spring Meeting will this year be held in Cleveland, Ohio, and committees are already actively at work on the preparations. An Executive Committee has been formed, consisting of Past-President Ambrose Swasey, Chairman, R. H. Fernald, Vice-Chairman, F. W. Ballard, Secretary, R. B. Sheridan, Treasurer, Worcester R. Warner, Past-President, S. T. Wellman, Past-President; E. P. Roberts, G. E. Merryweather, and A. G. McKee, with the following sub-committees: Finance: R. B. Sheridan, Chairman; J. D. Cox, A. B. McNairy, A. Ward Foote, George Bartol, E. H. Whitlock; Entertainment: R. H. Fernald, Chairman; W. R. Warner, S. T. Wellman, Chas. F. Brush, F. A. Coleman, C. E. Pope, H. H. Hill, S. R. Sague, H. F. Stratton; Publicity: E. P. Roberts, Chairman; H. M. Lane, R. I. Clegg, David Gaehr, Geo. R. Murray, F. H. Vose; Transportation: Geo. E. Merryweather, Chairman; S. A. Hand, Geo. R. Wadsworth, H. B. Anderson, C. C. Robbins; Accomodations: Arthur G. McKee, Chairman; H. M. Lucas, W. J. Reilly, Albert H. Bates, E. C. Peck. The committee is preparing interesting literature in connection with the history of the Society and the points of commercial and historical interest of Cleveland.

In this connection the Committee on Meetings announce that, in view of the plans under way for the professional sessions, the latest date at which papers can be received for the Spring Meeting will probably be April 15.

COMING MEETINGS

PHILADELPHIA MEETING, MARCH 7

On March 7 the Society will coöperate with the Franklin Institute in a meeting on the Electrification of Main Line Railways. Wm. J. Clark, manager of the traction department of the General Electric Company, New York, will address the meeting.

NEW YORK MEETING, MARCH 12

At the meeting of the Society in New York on March 12, Practical Problems in Tap and Screw Making will be presented by Frank O. Wells, president and treasurer of the Wells Brothers Company, Greenfield, Mass. The importance of size and lead in the cost of assembling manufactured work will be treated, as well as the practical limits of accuracy, reasons for abandoning the V-thread, the proper size of tap drills, the power required for tapping, the effect of lubricants on size and power, and other interesting points.

A number of prominent tap makers, including members of the Tap Makers Association, have been invited to discuss the subject and have expressed their desire to attend, and it is expected that the meeting will bring out much interesting data.

BOSTON MEETING, MARCH 15

A paper upon Results of Tests on the Discharge Capacity of Safety Valves, by Prof. E. F. Miller, professor of steam engineering at the Massachusetts Institute of Technology, and A. B. Carhart, superintendent of the Crosby Steam Gage & Valve Company of Boston, will be presented at a meeting of the Society in Boston on March 15.

NEW HAVEN MEETING, APRIL 17

A meeting of the Society will be held in New Haven on the afternoon and evening of Wednesday, April 17, in the Mason Laboratory of Mechanical Engineering. The topic for consideration will be The Cost of Production.

REPORTS OF MEETINGS

ST. LOUIS MEETING, FEBRUARY 7

A meeting of the Society was held in St. Louis on February 7, in which other engineering societies having representatives in that city were invited to coöperate. A paper on A Comparison of Air Braking Systems for Urban Electric Railway Cars, by Charles W. Young and Charles A. Hobein, both of the United Railways Company, St. Louis, was read by the latter, which described the two systems commonly used for single cars in modern city service, and gave data on investment, operation, maintenance and depreciation costs.

The paper was discussed by Richard McCulloch, vice-president and general manager of the United Railways Company, John Hunter, Mem. Am. Soc. M. E., chief engineer of the Union Electric Light & Power Company, F. A. Berger, Mem. Am. Soc. M. E., assistant professor of mechanical engineering at Washington University, A. L. Langsdorf, professor of electrical engineering and dean of the school of engineering, Washington University, G. W. Lamke, instructor in electrical engineering, Washington University, M. L. Holman, Past-President Am. Soc. M. E., consulting engineer, Professor Van Maur, and Mr. Metzger.

NEW YORK MEETING, FEBRUARY 13

The American Institute of Mining Engineers coöperated in a meeting of the Society held in the Engineering Societies Building on Tuesday evening, February 13, when a paper on the Design and Mechanical Features of the California Gold Dredge, by Robert E. Cranston, was presented by E. Gybbon Spilsbury, a member of both the organizations.

The paper gives detailed information in regard to all conditions necessary for the design of a gold dredge, and describes the present California type, which is a combination of the New Zealand type and several others. The buckets are made with a cast steel base, pressed steel hood and manganese steel lip. The lower tumbler is a six-sided steel casting with renewable wearing plates over which the buckets pass. They then travel up a structural steel ladder on rollers and over a six-sided upper tumbler which is driven by a chain of cast-steel gears. The buckets dump their material into a hopper which discharges into a shaking or revolving screen. The fine material goes through onto gold-saving tables and the coarse material is stacked aft of the dredge by means of a belt conveyor. The dredge is held in place by steel spuds and moved by means of side lines running to a motor-driven winch. The digging ladder is raised by means of a separate winch driven by the digging motor. Water is furnished under pressure by motor-driven centrifugal pumps. The hull is built of Douglas fir and should be designed last.

The paper was illustrated by lantern slides, as was also a discussion by Charles Whiting Baker, editor of Engineering News, who showed the types of dredge used in the work on the Panama Canal. H. D. Hibbard of Plainfield, N. J., George A. Orrok of New York, R. M. Stanton, Jesse M. Smith, Past-President of the Society, John M. Sherrerd of the Taylor Iron & Steel Company, High Bridge, N. J., and A. F. Lowy also discussed the paper.

PHILADELPHIA MEETING, FEBRUARY 14

A meeting of the Society was held in Philadelphia on February 14, in which the Engineers Club, the Franklin Institute and the Society of Automobile Engineers coöperated. Charles Y. Knight, inventor of the Knight silent motor, was the speaker of the evening.

The problem he set out to solve, he said, was the development of a quiet or silent internal-combustion engine for automobiles, previous developments of the slide-valve type of internal-combustion engine having been abandoned on account of the inability to obtain proper lubrication. In Europe the roads are much straighter and have a better surface than our roads and maximum speed can be maintained for a longer period of time, and the block test, therefore, of the automobile motor in the best shops is very much more severe than it is here. He described the test of his motor before the Royal Society and stated that the sleeve-valve motor of his design ran through the continuous test of five nights and six days, developing an actual horsepower of 54.2 by his 38 h.p. English rated motor and 34 and a fraction h.p. with his 22 h.p. English rated motor and that after this block test the motors were placed in cars and run on the track 4000 miles and taken down and calipered, and showed no appreciable wear. He showed from sections thrown on the screen the valve action and the effect of the split ring in the top of the cylinder, and laid special stress on the absolute necessity of close-fitting pistons and gave the figure of 0.003 in. as a proper clearance. He also said that this same clearance was allowed between the sleeves and that with this clearance a film of oil was easily maintained and gave ample lubrication.

One of the advantages of the sleeve valve motor which he claimed was the avoidance of irregular sections in the cylinder design which under load conditions warped from their original shape and caused the pistons to seize or require additional clearance between pistons and cylinder. The sleeves of his engine, he said, would give slightly from their original shape and instead of having simply 0.003 in. of clearance for allowable warpage of cylinder wall, he practically had 0.009 in. The tops of his cylinders were machined all over, as well as the tops of the pistons, giving uniform clearance in each cylinder and presenting a machine surface which is not apt to hold carbon as a plain cast surface.

At the close of the meeting a unanimous vote of thanks was given to Mr. Knight for his address.

BOSTON MEETING, FEBRUARY 16

A meeting of the Society was held in Boston on Friday evening, February 16, when the subject of Aviation was presented in a paper by Albert A. Merrill, embodying the results of his extended study and experiments in this field. Mr. Merrill went very fully into the principles governing the construction of aeroplanes, especially with reference to stability and control, and advocated developing control along the lines indicated by the instinctive movements of the operator. With the aid of numerous slides he traced the progressive development of various types of control and described the improvements in this particular developed by himself.

His presentation was followed by an informal discussion.

EDISON MEDAL FOR GEORGE WESTINGHOUSE

At the meeting of the board of directors of the American Institute of Electrical Engineers, held January 12, the Edison Medal Committee reported that the Edison gold medal for the year 1911 had been awarded to George Westinghouse, Hon. Mem. Am. Soc. M. E., "for meritorious achievement in connection with the development of the alternating-current system for light and power." The medal will be presented to Mr. Westinghouse at a meeting to be arranged.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The Armour Institute of Technology Student Branch was addressed by Calvin W. Rice, Secretary of the Society, on January 31, his subject being the work of the Society and the advantages it offers to student branches.

On February 7, K. M. Boblett, Mem. Am. Soc. M. E., spoke on Automobile Radiators, and his lecture was illustrated by samples and models of various types of radiators. The radiating effect of each type, as well as the details of construction with reference to efficiency and economy of manufacture, were fully dealt with. A discussion followed.

CORNELL UNIVERSITY

Sibley College Student Branch held a meeting January 15, when Howard D. Hess, Mem. Am. Soc. M. E., read a paper on Some Recent Developments in Iron and Steel Manufacturing. The talk was illustrated with a number of lantern slides.

On January 24 the mechanical and electrical societies coöperated in a meeting at which Professor Sampson read selections and Professor Brown talked on Chemistry and Its Relation to the Engineer, with special reference to radio-activity.

LELAND STANFORD, JR., UNIVERSITY

The Stanford Mechanical Engineering Association recently elected the following officers for the coming semester: C. W. Scholefield, chairman; C. P. Campbell, vice-chairman; V. W. Winter, secretary-treasurer.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On December 12 the Mechanical Engineering Society of the Massachusetts Institute of Technology held a meeting at which A. R. Davis and D. Dasso, Students, 1911, presented a paper on High-Speed Gasolene Engines. Mr. Davis discussed the general theory of the different types of engines, features of different carbureters and ignition systems; while Mr. Dasso considered a dozen different engines, most of which were of foreign design, discussing the good and objectionable features of each.

OHIO STATE UNIVERSITY

At a meeting of the Ohio State University Student Branch on January 15, the paper by S. H. Bunnell on Expense Burden was discussed.

On January 22, the following officers were elected for the coming semester: J. P. Stewart, chairman; J. Tom, vice-chairman; H. F. Belt, secretary; G. Burrell, treasurer.

POLYTECHNIC INSTITUTE OF BROOKLYN

On February 3 the Student Branch of the Polytechnic Institute of Brooklyn held a meeting at which Mr. Maujer of Power presented a paper on Power Plants in the West. W. D. Ennis, A. A. Adler and G. A. Orrok discussed the paper.

On February 10 the De La Vergne Company's plant was inspected by the students.

STATE UNIVERSITY OF KENTUCKY

The Student Section of the State University of Kentucky held a meeting January 9, at which Calvin W. Rice, Secretary of the Society, gave an address on the work of the Society and the benefits of the membership in it.

STEVENS INSTITUTE OF TECHNOLOGY

Charles N. Chadwick of the Board of Water Supply of New York City, lectured before the Stevens Engineering Society, February 8, on the Water Supply of a Great City. The Catskill Aqueduct was described in a very instructive manner and the lecture was illustrated by lantern slides.

On February 18 Thomas Travis gave a talk on The Criminal from a Scientific Standpoint. Calvin W. Rice, Secretary of the Society, introduced the speaker.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Section held its regular monthly meeting, February 9. Walter W. Franz, Mem. Am. Soc. M. E., gave an interesting talk on the university's new power plant, designed by him. The plant was afterwards inspected by the members present, the student branch of the American Institute of Electrical Engineers being the guests of the evening.

UNIVERSITY OF ILLINOIS

The University of Illinois held a meeting January 12, at which E. P. Bradley read a paper on The History and Development of the Vacuum Heating System. A general discussion followed.

UNIVERSITY OF KANSAS

On January 8, Calvin W. Rice, Secretary of the Society, spoke before the Student Branch of the University of Kansas on the advantages offered by membership in a body. One of the papers of the evening was Tests of Large Boilers at the Detroit Edison Company, by D. S. Jacobus, presented by C. G. Martinson, Student, 1910. A discussion by Perley F. Walker, Mem. Am. Soc. M. E., followed. The Plant of the Bucyrus Company in South Milwaukee, by E. Carson, and The Manufacture of Waterman Fountain Pens, by P. L. Reymond, Student, 1911, were also presented.

On January 26 the following papers were presented: J. M. Jenks' Valve Gear for Gas Engines, Mr. Kleigh; Producer Gas from Crude Oil, V. H. Hilford, Student, 1911; Automobile Engines, Mr. Angevine; Stubbers Gas Machine, A. H. Sluss. The last consisted of a talk on the design and construction of a constant pressure gas machine, invented by a man with no technical skill.

UNIVERSITY OF MISSOURI

Tests of Large Boilers at the Detroit Edison Company, by D. S. Jacobus, was read and discussed at a meeting of the Student Branch of the University of Missouri on January 22.

Officers elected for the coming semester were: A. C. Edwards, chairman; F. I. Kemp, secretary-treasurer; P. A. Tanner, corresponding secretary.

YALE UNIVERSITY

The Mechanical Engineers' Club of Yale University held a meeting on February 6, when a paper was read by B. W. Hill, Student, 1911, on Farming by Mechanical Power. It was illustrated by lantern slides and demonstrated the superiority of mechanical power over horse power in farming.

MEETING OF THE COUNCIL

A meeting of the Council was held on February 13 in the rooms of the Society. There were present, Alex. C. Humphreys, President. presiding; Ira N. Hollis, E. B. Katte, F. R. Hutton, E. D. Meier, George A. Orrok, Jesse M. Smith, T. B. Stearns, H. H. Vaughan, R. M. Dixon, Calvin W. Rice, Secretary, and, by invitation, George J. Foran, Chairman of the Committee on Membership, and I. E. Moultrop, Chairman of the Committee on Increase of Membership. Regrets were received from H. G. Reist, D. W. Crawford, and Stanley G. Flagg.

The minutes of the meeting of January 9 were read and approved.

The President announced the following additional committee appointments: Finance Committee, W. D. Sargent; New York Committee on Meetings, H. R. Cobleigh; Tellers of Election, George L. Hoxie and Theo. Stebbins.

The deaths of E. K. Sancton and W. F. Buck were reported.

The conduct of the Annual and Semi-Annual Meetings were discussed and it was the sense of the Council that the Annual President's Reception be made a function of the Society and the expense of same charged to the appropriation of the House Committee.

Voted: That the budget appropriation for the House Committee be increased by $551.53 in the current fiscal year, to cover the expenses of the President's Reception in December 1911.

The Council devoted considerable attention to ways and means of extending the Society's usefulness to a larger circle of the profession and the policies recommended by I. E. Moultrop, former member of the Council and chairman of the Committee on Increase of Membership, were in general favored. The Committee on Increase of Membership and the Membership Committee, George J. Foran, Chairman, were invited to prepare a statement and submit to the Council at the earliest possible date.

The Research Committee submitted to the Council the recommendation that the Council authorize the procedure of an investigation of the laws governing the transmission of heat through metallic tubes:

Resolved: That the Council considers further investigation of the laws governing the transmission of heat through metallic tubes highly interesting and important, and heartily endorses a consideration of that subject by the Research Committee; while the Council wishes to commend the promotion of all such work on the part of the Research Committee, it is to be regretted that the Society has not the available money for such purpose.

Voted: To approve the recommendation of the Publication Committee that the price of The Journal be made $3 to every one not a member or an affiliate of The American Society of Mechanical Engineers, and that the Secretary be directed to amend any previous action of the Council directing otherwise.

Voted: That the request of the St. Louis Committee on Meetings, to organize under the provisions of C 52 for formation of geographical sections be referred to the Executive Committee for report back to the Council.

Voted: That the communication from the Institution of Civil Engineers of Great Britain, asking that the American Society join in the erection of a memorial window to Lord Kelvin in Westminster Abbey, be referred to the President with power.

Voted: To approve the formation of a Student Branch at the University of California, Berkeley, Cal.

On motion the meeting adjourned.

SOME TESTS ON CARBURETERS

By George W. Munro

ABSTRACT OF PAPER

The paper outlines the problem of carburation for motor vehicle engines and points out the difficulties met in determining the performance of a carbureter as distinct from the performance of the engine to which it is attached.

Results of 400 economy tests on a single engine served by six different carbureters under identical conditions of speed and load are presented in graphical form. By these it is shown that the performance characteristics are different with the different carbureters and that the carbureter characteristics would be determined if those of the engine on which they are superposed were known. Approximate engine characteristics are developed for comparison by using the best performance obtained with any carbureter.

Attention is called to the economic importance of the carbureter, the desirability of applying more scientific methods in its development, and the necessity of having available a testing plant, the constants of which are well determined.

SOME TESTS ON CARBURETERS

By George W. Munro, Lafayette, Ind.

Affiliate of the Society

The carbureter used on vehicle motors is a machine for mixing liquid gasolene with air in such proportions that the motor will always be supplied with combustible mixture suitable for explosive burning behind the engine piston. For satisfactory service it must respond automatically to the engine demand, whether light or heavy; and must be so well designed and built as to function under the most trying conditions of vibration and jar, and in any position less than complete overturn. Its action must not be seriously affected by weather conditions and provision must be made for meeting readily wide variation in character of fuel supply.

2 Increase in demand may result either from additional load or increase in piston speed. The heavy load at low-speed results in an intermittent carbureter action, while at the higher speeds the flow of mixture to a multiple-cylinder motor is nearly continuous. So in addition to responding to a quantity change, the carbureter must also meet a variation in the character of the demand.

3 Until recently, effort was centered in meeting these operative conditions, and but little consideration was given to cost of operation. With the growing popularity of the automobile and motor boat, however, and the advent of a number of carbureters giving satisfactory service, questions of fuel economy arose, demanding comparative tests and performance. Here the lack of established methods of testing, the absence of standards of comparison and even a too limited nomenclature, prove troublesome.

THE PROBLEM OF CARBURETER TESTING

4 The peculiar features of the problem are that a carbureter is used only in connection with an engine and so should properly be tested in use upon it, thus introducing engine characteristics into all results. Again, the engine requires a carbureter for operation, and so its performance can not be determined free from carbureter factors. From this it appears that the two must be tested together,

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and the securing of a proper standard for comparison of results is most important.

5 As the best possible performance of the engine marks also the best possible carbureter action, the complete determination of the engine characteristics would establish a basis for comparing the behavior of any carbureter which might be used. Owing, however, to the fact that the characteristics of some carbureters are always superimposed on those of the engine, the limitations due to such purely engine factors as compression, shape of the clearance space and friction, can not be readily determined. However, if an engine were tested under the same running conditions with a large number of carbureters, some one of them might furnish a perfect mixture and the best possible performance of the engine would be realized. The repetition of this process with a large number of running conditions would ultimately result in defining completely the engine performance.

6 It is too much to expect that this result could be accomplished by testing only six carbureters, but lacking any other standard the best result obtained under each running condition has been plotted on each sheet of results for comparison.

SCOPE OF THE WORK

7 The six carbureters were tested under identical engine conditions through a range of ten speeds from 300 to 1200 r.p.m. At each speed, tests were run with 10, 20, 30, etc., lb. net load on the brake up to the maximum which could be carried, making 80 tests with each carbureter.

8 The impossibility of maintaining all the conditions and lack of time made it impossible to complete all of the series, but a total of 401 tests was secured, with results so consistent as to indicate the essential accuracy of the work. In addition, the experimental work involved the repetition of one entire carbureter series, due to a broken crankshaft and consequent change of engines after the work with the first carbureter had been completed. A seventh carbureter was also tested, the results of which are omitted for reasons discussed elsewhere.

THE CARBURETERS

9 The carbureters, selected to represent as widely different types as possible, covered the standard construction of the different manufacturers at the time they were loaned or donated for the purpose of the investigation. The details of carbureter con-

struction have changed so rapidly, however, in the two years since, that the results should now be interpreted as applying to the type of instrument, rather than to the particular output of any manufacturer.

10 Carbureter *A* (Fig. 1) is a concentric float-feed, single-jet, auxiliary air-valve carbureter in which the auxiliary air supply is regulated by an adjustable spring controlling a light flat-seat metal valve.

11 Carbureter *B* (Fig. 2) is a concentric float-feed, single-jet type with floating ball auxiliary air valves, in which the auxiliary air enters by raising the ball valves in their cages in response to the suction caused by increase of engine demand. Both these carbureters have many points of resemblance and were chosen because of the difference in auxiliary air control.

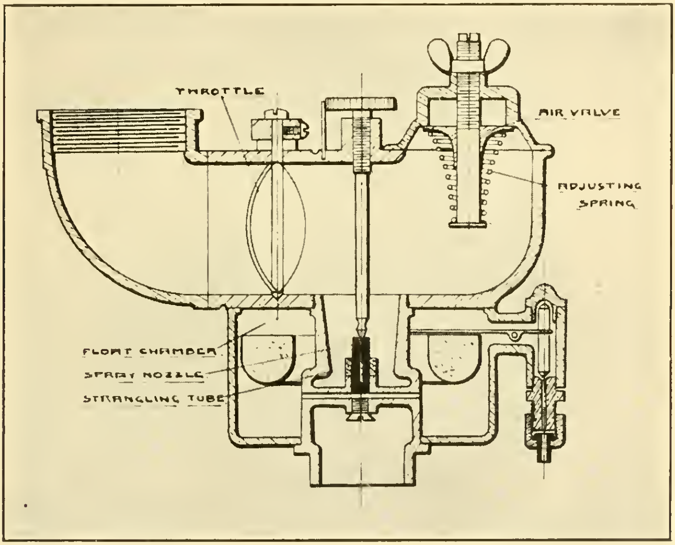

FIG. 1 CARBURETER *A*

12 Carbureter *C* (Fig. 3) is of the concentric float feed type, but has no needle valve, the adjustment for fuel characteristics being made by changing gasolene nozzles. The auxiliary air valve is controlled by two springs, one of which comes into action only under conditions of high demand. Carbureters *A*, *B* and *C* have in common the same general design features; a gasolene nozzle with constant level fuel supply around which passes an unregulated air current,

the air velocity being increased at the nozzle tip by a constriction of the air passage at that point. As this device gives a mixture too rich to be explosive at all except under the conditions of lightest demand, provision is made for the admission under automatic control of additional air to dilute the mixture to required proportions. The notable differences consist of various automatic air controls, fuel controls to the nozzles and forms of the constant air supply passages. Of these the automatic air control was considered the most important and was the controlling factor in the selection of these carbureters for this work.

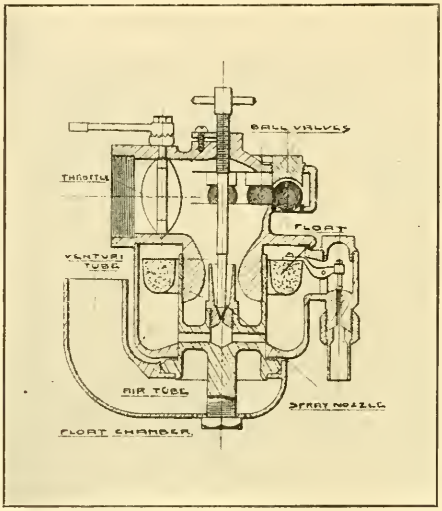

Fig. 2 Carbureter *B*

13 Carbureter *D* (Fig. 4) is a float-feed, two-jet, automatic-valve type, the automatic valve operating to keep one jet from service except under conditions of high demand. When the demand increases beyond the capacity of the first nozzle, the increased suction opens the valve above the second jet, which is of the cone multiple spray type, additional mixture being thus secured.

14 Carbureter *E* (Fig. 5) is a float-feed, multiple-jet type with floating venturi air tubes surrounding the nozzles. The jets, four in number, are successively brought into action as the piston throttle is operated to uncover their ports, the floating of the air tube being intended to maintain constant quality of mixture throughout the range of each jet.

15 Carbureter *F* (Fig. 6) is of the concentric float feed, puddling type, a gasolene puddle being formed in the bottom of the U-shaped air passage under conditions of light demand. With increased demand the puddle disappears by evaporation, the fuel supply being restricted by the needle valve. No auxiliary air supply is provided in this carbureter, the puddle furnishing mixture sufficiently rich for starting with air supply wide open.

16 Carbureter *G* is one of the very early machines equipped with a lifting needle under control of the throttle. Its behavior on test leads to the belief that it is not representative of the type and so no interest attaches to the results, which are not given. It is mentioned here only because it gave maximum economy under a number of conditions, which results have been plotted for comparative purposes.

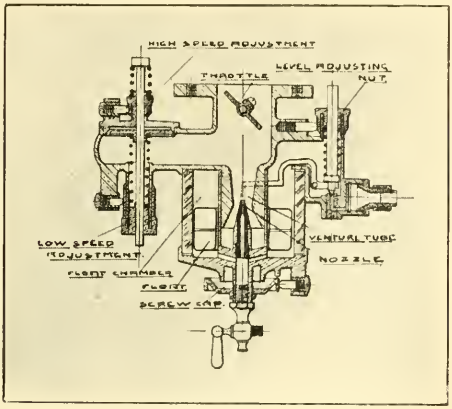

Fig. 3 Carbureter *C*

TESTING PLANT

17 The tests were made on a new Rutenber 4-cylinder, 4-cycle automobile engine. The cylinders, $4\frac{1}{2}$ in. in diameter by 5 in. stroke, were each equipped with a single spark plug and the timer controlling the ignition system was provided with a pointer and scale, showing the ignition point with reference to the inner dead center in degrees of crankshaft position.

18 The power was measured and absorbed by a prony brake having an arm of a 2.1875 ft. radius, bearing on platform scales. An oil drip on the brake-wheel rendered the brake very sensitive and eliminated all tendency of the engine to "hunt."

19 Speed was determined by an indicating tachometer carefully calibrated for the speeds to be maintained.

20 The fuel, ordinary stove gasolene, had a specific gravity of 0.723 and was supplied from a vertical cylindrical tank having a gage glass and scale properly calibrated.

21 The cooling water for the motor was stored in a large tank out of doors and after use was discharged to the sewer.

22 The operation of the plant was in every way satisfactory and conditions of speed and load, once established, could be maintained constant as long as desired.

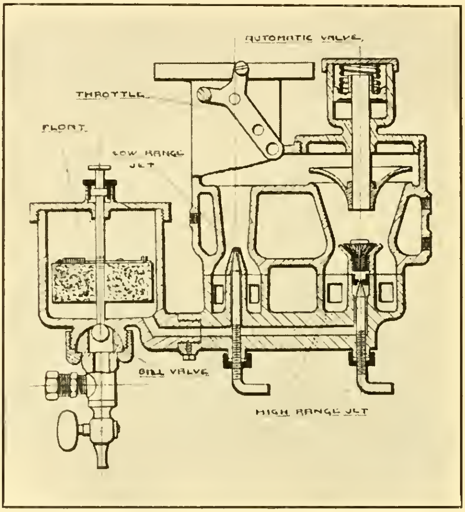

Fig. 4 Carbureter *D*

ADJUSTMENT

23 In preparing for the tests the engine was "tuned up" by adjusting the carbureter for range and economy as follows: To maintain the maximum load at 1200 r.p.m.; to give least possible fuel consumption under maximum conditions; to run light at 300 r.p.m. or slower; to accelerate properly when the throttle was opened quickly; and to attain all intermediate conditions under throttle and spark control without misfires, backfires or noticeable smoke at the exhaust. This "tuning up" with each carbureter in turn was done by a man of experience and skill, and it is believed that the adjustments were uniformly good.

THE TESTS

24 After adjustment the speed was brought to 300 r.p.m., the brake load adjusted to 10 lb., the cooling water regulated to give desired conditions and a 6-minute test made, readings of fuel consumption and temperature of outgoing cooling water being taken at 1-minute intervals. The temperatures of the room and incoming cooling water remained nearly constant and were taken only at the beginning and end of each test.

25 The tests were made in the order of increasing loads and speeds, that is, the load was increased at constant speed to the engine capacity when the speed was increased by 100 r.p.m. and the load series repeated. At all times the engine was given the most advantageous spark setting, ignition adjustment being made before each test. No adjustment of cooling water supply was made during a load series unless there seemed danger that the boiling point would be reached before the series was concluded. This shows in a gradually increasing temperature of outgoing cooling water through each load series.

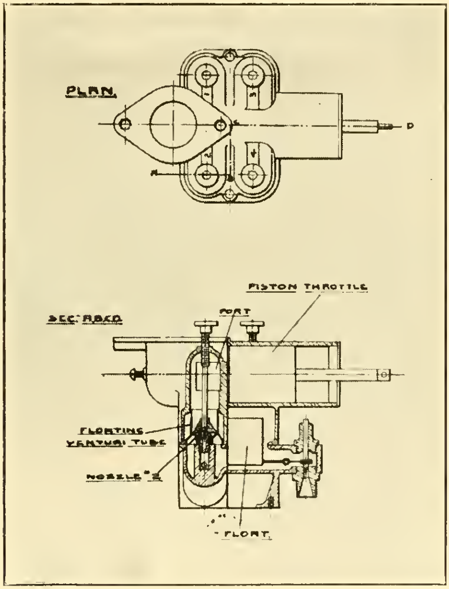

Fig. 5 Carbureter *E*

26 After the ten load series were completed, a "range test" was

made, the carbureter adjustment remaining the same as throughout the economy tests. Maintaining the maximum load which the engine would carry at 1200 r.p.m., the speed was gradually decreased by throttle and spark to the lowest point at which the load could be carried. The results are given graphically in Fig. 14.

THE RESULTS

27 The results of all tests are given in graphical form in Figs. 7 to 12 inclusive. The graphical method followed in presenting results has the advantage of being concise and of furnishing certain comparisons in the process of presentation; whereas tabulation of the same data requires a quite bewildering mass of figures from which comparisons are drawn only with difficulty. In the matter of accuracy there is some advantage in tabulation, yet here the gain is not so great as might appear. Take, for example, the fuel consumption per hour which has been plotted to tenths of a pound, while the fuel reading was originally made to hundredths of a pound for a one-tenth hour test, making the plotting of the same accuracy as the original observation.

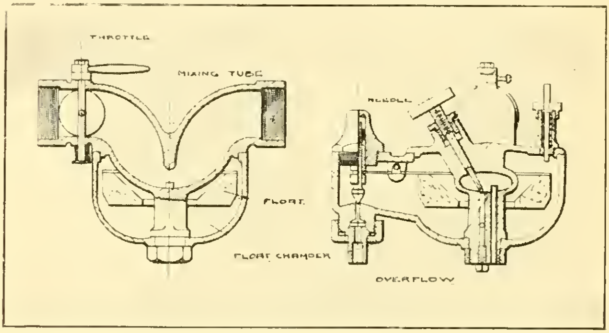

Fig. 6 Carbureter *F*

28 An inspection of the result sheets shows that for each load series, there might be drawn a smooth curve which would show the performance characteristic of the carbureter for that speed. These curves were not drawn in as it did not seem wise to confuse the presentation of data with its interpretation, but to illustrate the characteristics of the various carbureters Fig. 13 has been drawn giving the results obtained from all carbureters at 1100 r.p.m. Comparison of these curves with the results obtained from the same carbureters at nearby speeds shows that they are typical forms.

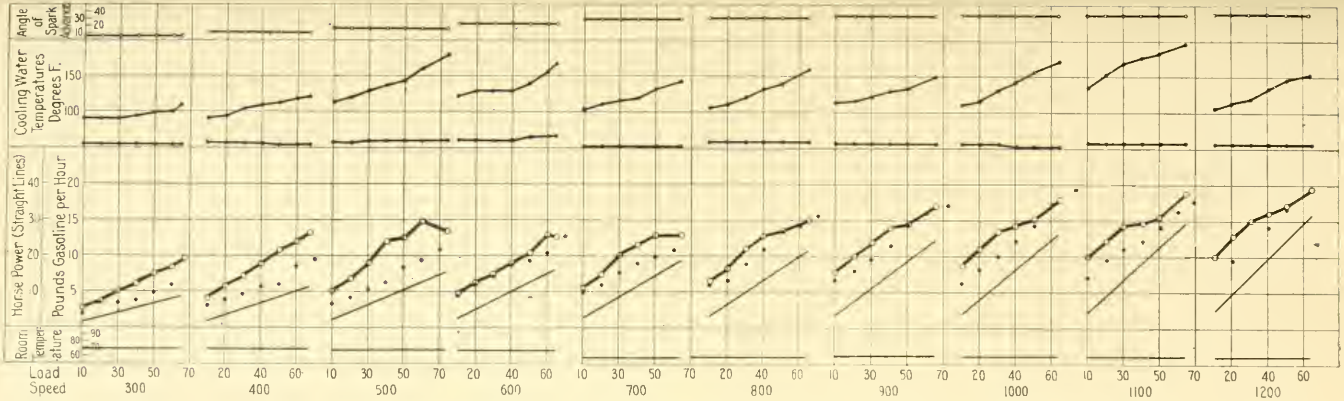

FIG. 7 RESULTS OF TESTS WITH CARBURETER *A*. BEST PERFORMANCE OBTAINED FROM ANY TEST INDICATED BY SOLID DOT

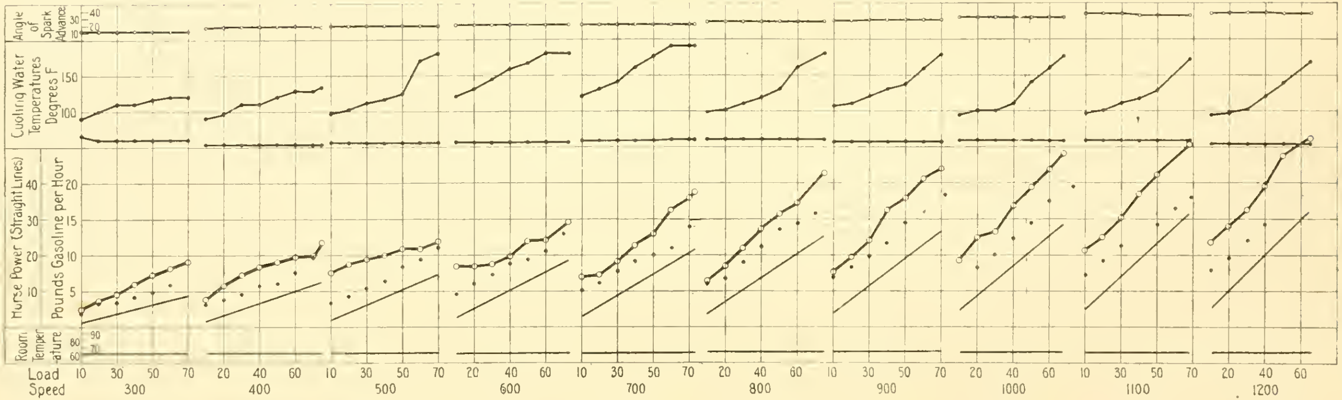

FIG. 8 RESULTS OF TESTS WITH CARBURETER *B*. BEST PERFORMANCE OBTAINED FROM ANY TEST INDICATED BY SOLID DOT

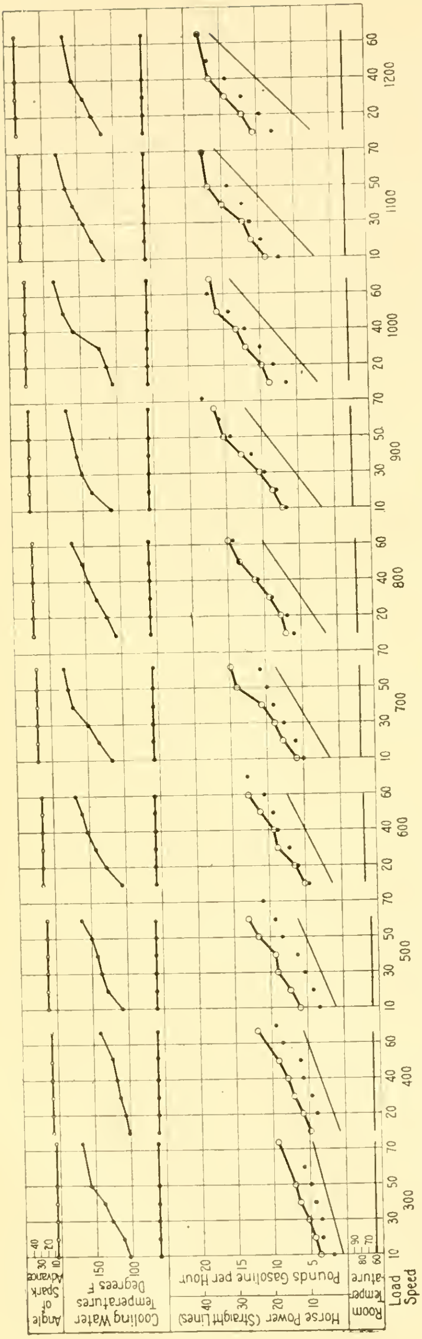

FIG. 9 RESULTS OF TESTS WITH CARBURETER *C*. BEST PERFORMANCE OBTAINED FROM ANY TEST INDICATED BY SOLID DOT

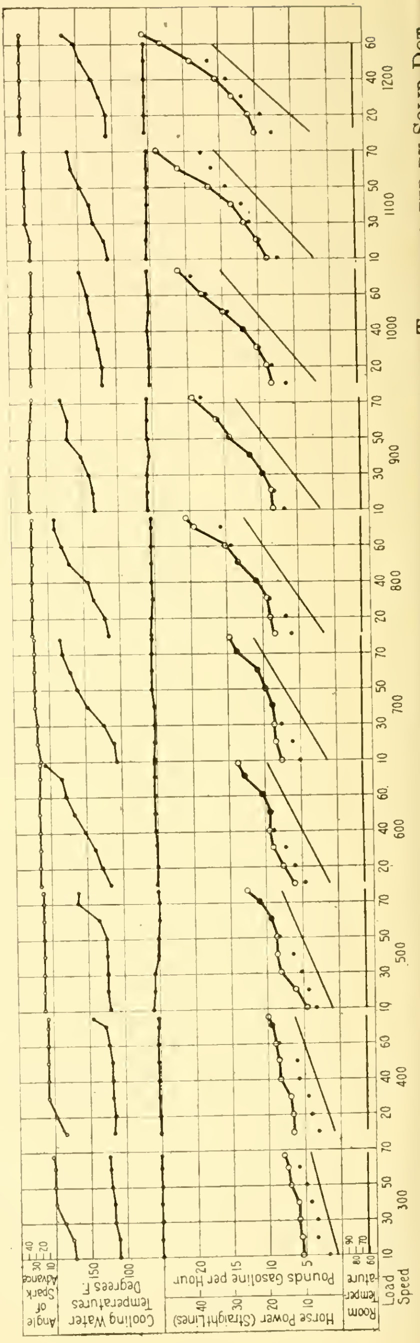

FIG. 10 RESULTS OF TESTS WITH CARBURETER *D*. BEST PERFORMANCE OBTAINED FROM ANY TEST INDICATED BY SOLID DOT

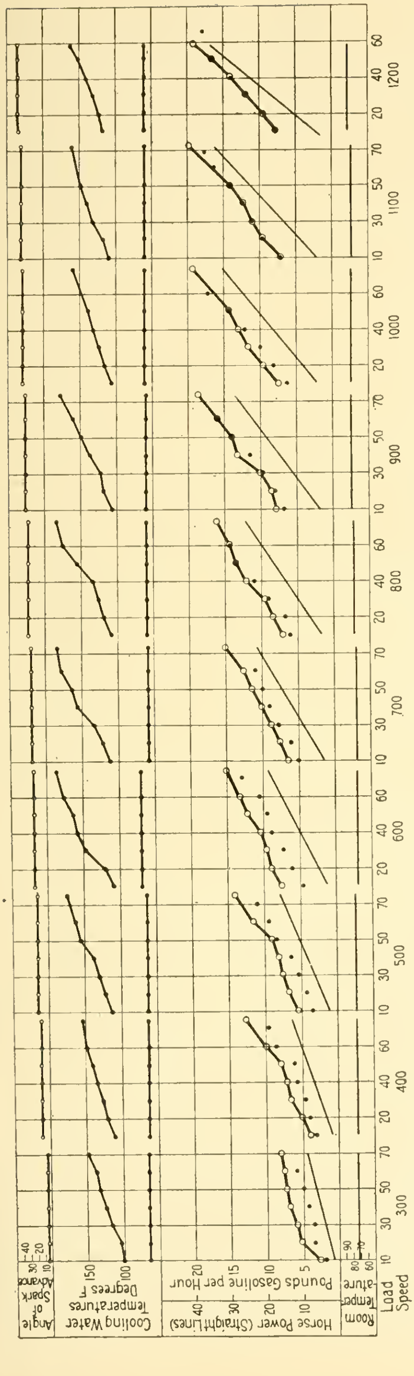

Fig. 11 Results of Tests with Carbureter *E*

Best Performance obtained from any Test indicated by Solid Dot

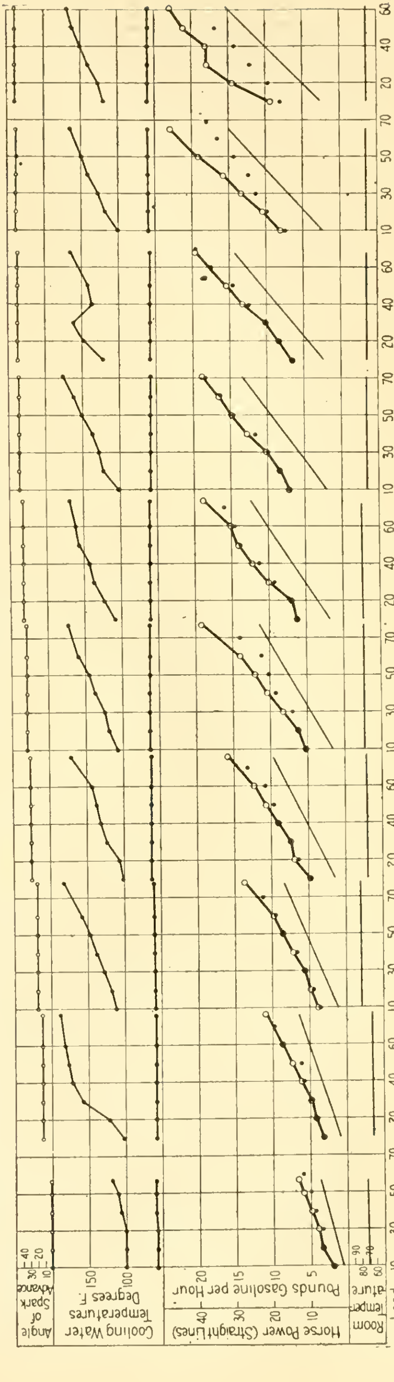

Fig. 12 Results of Tests with Carbureter *F*

Best Performance obtained from any Test indicated by Solid Dot

ENGINE PERFORMANCE

29 As previously indicated, the best performance of the engine has a special interest in a series of carbureter tests as it forms the only available basis for comparison of carbureter action. For this reason as well as because of the interest that naturally attaches to records of engine performance, the best engine results at each speed have been shown graphically in Fig. 14, both in terms of gasolene per brake horsepower-hour, and in per cent thermal efficiency, based on an assumed calorific value of 20,700 b.t.u. per lb. of gasolene.

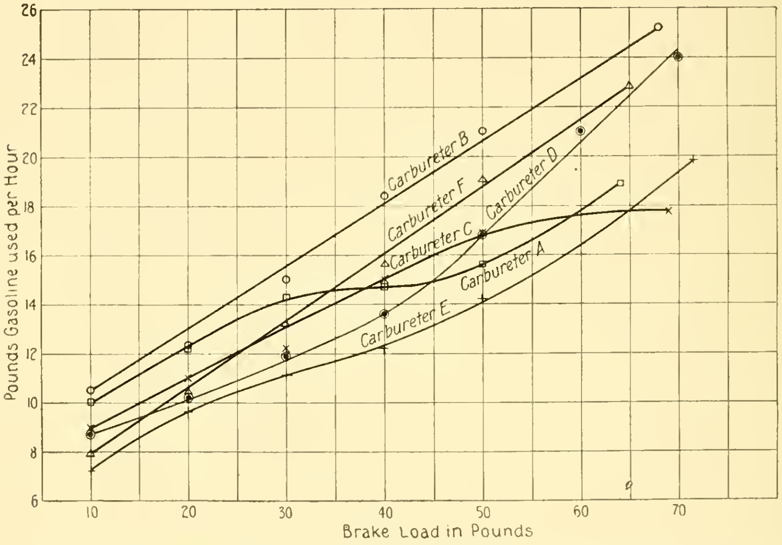

FIG. 13 CURVES SHOWING CARBURETER CHARACTERISTICS AT 1100 R.P.M.

Also the best results obtained with each load at 800 r.p.m. have been shown in Fig. 15 in the same way. Smooth curves have been drawn to assist the eye in following the points and to indicate the general trend of results. The best performance with any one carbureter has been indicated by black dots in each case for comparison.

30 Table 1 shows the maximum horsepower developed at each speed with each carbureter, together with the corresponding fuel consumption and engine efficiency.

31 The best performance, 22.2 per cent, corresponds to a fuel consumption of 0.736 pints of gasolene per horsepower hour. The highest brake load, 78 lb., demands a mean effective pressure of 81 lb. to the square inch for the brake load alone. Assuming a mech-

TABLE 1 MAXIMUM POWER AND ENGINE PERFORMANCE AT EACH SPEED WITH EACH CARBURETER

R.P.M.	300			400			500			600			700			800			900			1000			1100			1200		
Carbureter	Horsepower	Lb. Gasolene per hr.	Efficiency per cent	Horsepower	Lb. Gasolene per hr.	Efficiency per cent	Horsepower	Lb. Gasolene per hr.	Efficiency per cent	Horsepower	Lb. Gasolene per hr.	Efficiency per cent	Horsepower	Lb. Gasolene per hr.	Efficiency per cent	Horsepower	Lb. Gasolene per hr.	Efficiency per cent	Horsepower	Lb. Gasolene per hr.	Efficiency per cent	Horsepower	Lb. Gasolene per hr.	Efficiency per cent	Horsepower	Lb. Gasolene per hr.	Efficiency per cent	Horsepower	Lb. Gasolene per hr.	Efficiency per cent
A	8.138	9.6	10.4	11.122	13.2	10.3	15.429	13.4	14.1	16.276	12.7	15.8	18.688	13.0	17.7	21.678	15.0	17.8	24.602	17.0	17.8	26.688	18.0	18.2	29.357	18.9	19.0	31.80	19.5	20.1
B	8.764	9.0	12.0	12.450	11.7	13.1	14.595	11.8	15.2	18.380	14.5	15.5	21.316	18.6	14.1	25.010	21.3	14.4	26.292	21.9	14.7	28.356	24.0	14.5	31.192	25.2	15.2	32.552	26.1	15.3
C	9.265	9.4	12.1	11.122	12.0	10.4	12.510	13.0	11.8	14.898	12.8	14.3	17.958	15.0	14.7	20.677	15.0	16.9	24.789	16.6	18.3	28.356	17.0	20.5	31.651	17.7	22.0	32.552	18.0	22.2
D	8.380	8.0	12.9	12.450	9.9	15.5	15.870	11.7	16.7	19.530	13.8	17.4	22.776	14.8	18.8	25.010	20.6	15.0	27.012	19.5	17.0	30.441	21.2	17.5	32.109	24.0	16.4	32.552	25.8	15.5
E	8.764	8.0	13.4	12.450	12.6	12.1	15.640	14.0	13.8	18.530	15.0	15.2	21.316	15.0	17.5	24.345	16.1	18.6	27.600	18.6	18.2	30.441	19.4	19.3	32.797	19.8	20.3	34.050	19.2	21.8
F	7.136	6.5	13.5	12.782	10.8	14.5	16.263	13.5	14.8	19.030	15.6	15.0	22.484	18.0	15.4	24.679	18.6	16.3	26.667	18.6	17.6	28.356	19.5	17.9	29.815	22.8	16.0	30.548	22.9	16.4

Efficiency based on assumed fuel value of 20,700 b.t.u. per lb.

anical efficiency of 85 per cent for the engine, the mean pressure on the piston would be 95 lb., which corresponds closely with the best that is obtained with the same fuel in stationary practice, and shows that conditions in the cylinder are not materially changed up to seven or eight cycles per second. Indeed, the steady increase of efficiency with speed, indicates that speed does not interfere with cylinder performance within the limits of the experiments.

CONCLUSIONS

32 A consideration of the results obtained leads to the following conclusions:

a Under identical conditions of speed and load an engine gives materially different fuel economy when served by different carbureters.

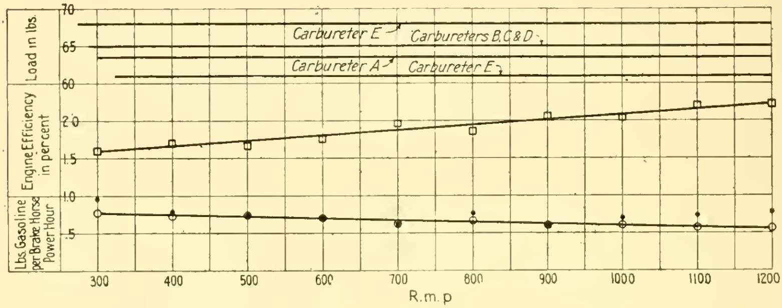

FIG. 14 CURVES SHOWING RESULTS OF RANGE TESTS AND BEST PERFORMANCE OF ENGINE AT EACH SPEED. BEST PERFORMANCE WITH SINGLE CARBURETER (CARBURETER *D*) INDICATED BY SOLID DOTS

b Carbureter action is the limiting factor in engine capacity as well as in economy.

c Wide range and perfect operation give no indication of fuel economy.

d Each carbureter has distinctive performance characteristics which may be determined and plotted.

e The characteristic may be such that a carbureter giving excellent results under some conditions may give very poor economy over a large part of its range.

33 Being the limiting element of engine capacity and economy, the carbureter is a machine of great engineering and economic importance and as such demands more scientific methods in its development than have yet been applied. This would necessitate

systematic testing and comparison, not only of widely different types, but of the same carbureter after minor changes in design.

34 A method of testing carbureters which would be independent of engine characteristics is much to be desired, as then results obtained by different experimenters in different places could be directly compared. Lacking such a method, it seems desirable that an engine be properly equipped and placed in some laboratory for the testing of carbureters, thus establishing, after the engine characteristics became thoroughly known, a definite standard available for reference. Such a standard would be valuable only in case carbureters retain their relative characteristics when transferred to different engines, which seems probable but has not yet been established experimentally.

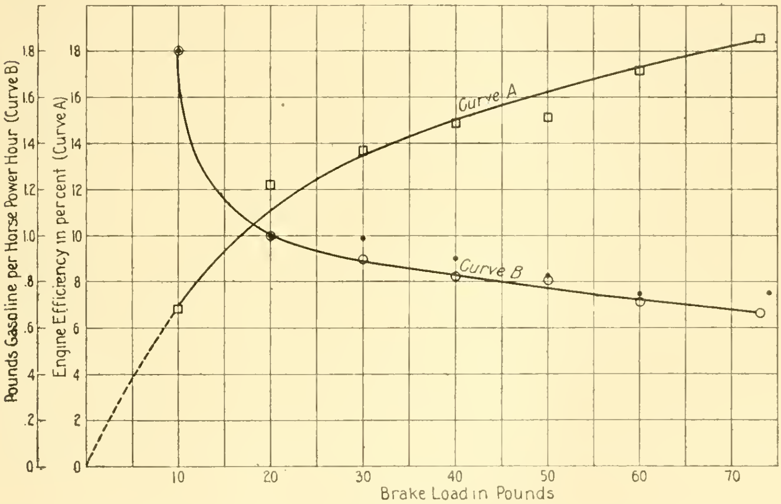

FIG. 15 CURVES SHOWING BEST PERFORMANCE OF ENGINE AT EACH LOAD SPEED CONSTANT AT 800 R.P.M. BEST PERFORMANCE WITH SINGLE CARBURETER (CARBURETER *F*) INDICATED BY SOLID DOT

35 This would require a large expenditure, both for plant and for operation and, undertaken as a commercial venture, would probably be attended with financial loss. Engine builders, however, spend vast sums each year in developing and perfecting their output, and when the dependence of the engine on the carbureter is considered, it would seem that several engine manufacturers might profitably unite in the systematic improvement of the carbureter.

Several states have established engineering experiment stations where problems of importance in the development of industries or the conservation of important natural resources may be thoroughly investigated, and the carbureter, important in both aspects, may properly receive their attention.

The experimental work on which this paper is based was performed in the spring of 1910 by Messrs. R. W. Noland, G. P. Rettig and J. A. Saurs, seniors in the School of Mechanical Engineering of Purdue University, in preparation of their graduating thesis. Mr. Noland had been for three years assistant in mechanical drawing at Purdue and Mr. Rettig had had a wide experience in the employ of automobile makers. Any value which the results possess is due primarily to his skill in "tuning up" an engine. It was done under the direct supervision of Mr. C. C. Austin, at that time an assistant in the gas engine laboratory, the author being in general charge of the work.

The engine upon which the tests were made was loaned for the purpose by the builders, the Western Motor Co. In addition to the experimental results the drawings of the carbureters tested are taken from the thesis.

SOME REFRACTORY SUBSTITUTES FOR WOOD

At the meeting of the Society held in Boston, November 16, 1911, the Boston Society of Civil Engineers and the Boston section of the American Institute of Electrical Engineers coöperating, a paper was presented by Prof. Charles L. Norton, Mem. Am. Soc. M. E., of the Massachusetts Institute of Technology, on Some Refractory Substitutes for Wood.[1]

The common use of wood in and around our buildings is responsible for a considerable part of the annual fire loss, and the discovery or invention of a satisfactory substitute which would possess the desirable properties of wood and yet be non-combustible has been long hoped for. It is clear that in order to be accepted as a substitute for wood in building construction, a new material must approximate in lightness, strength, elasticity and ease of working, the natural woods, and further, since the variation in natural woods fits them for special details of construction, the substitute must be had in different grades of hardness, toughness, fineness of texture, etc. Moreover the ease of working, sawing, boring, nailing and so on, leads to a wide use of natural wood, and a substitute to be acceptable must approximate the ordinary natural woods in these respects.

Many of the earlier attempts were made in the direction of altering the natural wood by some chemical treatment, so as to make it ignite with greater difficulty and burn more slowly and without much flame. These processes afforded a number of so-called fireproof woods. The principle underlying the chemical treatment was usually one of two. First, the wood was saturated with a solution which, on drying, left in the pores a salt capable of giving off a gas when heated, this gas being of such a nature as to be incapable of supporting combustion. Phosphate of ammonia and tungstate of soda were extensively used for this purpose. With thorough saturation the protection afforded the wood and adjoining portions of the structure was by no means insignificant; specimens of wood treated with phosphate of soda have been in the possession of the author for more than ten years, and after ten yearly tests show no signs of deterioration. Similarly some specimens of wood and cloth treated with tungstate of soda in 1903 have shown little or no loss in fire resistance. The main value of such chemical protection lies in its diminishing the volume of the resulting flames. When once thoroughly ignited, the fireproof wood burns more briskly than the natural untreated wood.

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[1] Published in abstract only. Complete report may be consulted in the rooms of the Society

The second method of chemical treatment was one in which such substances as alum were used in order to supply a considerable quantity of steam from the water of crystallization and also to encase the pores of cells with a solid refractory substance.

A still earlier procedure was that of protecting wood from contact with a combustion-supporting atmosphere by coating it with thin sheet metal, usually tinned iron or copper. For doors and shutters this was found very effective. More recently hollow metallic members for doors and trim and for furniture have been extensively used, with a considerable degree of success. They are of course non-combustible, and under ordinary exposure keep their shape fairly well.

The wooden lath is without doubt responsible for the rapid spread of fire in many buildings of the older types of construction, and the attempts to develop a substitute have resulted in the metal lath and in the so-called plaster boards. The former are eminently satisfactory as substitutes for wooden lath, their greatest defect being their liability to become weakened by corrosion in damp places when used with certain kinds of plaster. The plaster boards are made of plaster of paris and some fibrous binding material, often wool, hair, or jute. Some are made of superposed layers of wool, felt and plaster. All, however, contain so large a percentage of plaster or other non-combustible material that combustion proceeds very slowly.

There have been from time to time, in the last 30 years, attempts to make use of boards composed only of refractory, inorganic substances. In general, such boards have been composed of some fiber and a cementing medium. The most popular fibers for this sort of experimentation have been asbestos and mineral wool, the cements used including about all the common cements of both the air drying and the hydraulic types. Oxychloride of magnesium, the value of which as a cement was discovered some 50 years ago by Sorel, has been the favorite cement for experimenters because of its simple preparation, its quick hardening and great strength. For some reason, however, a large percentage of the oxychloride cement is variable in its properties and often defective. When mixed with sand or similar dense bodies the oxychloride is often satisfactory for long periods, but the experience of the author with mixtures of this cement with fibers, both organic and inorganic, leads to the conclusion that it is unstable and unsatisfactory. This is more probably the case when the boards are used in damp places or out of doors.

There next appeared a number of wood substitutes in which a fiber was bonded by silicate of soda, commonly known as waterglass. Some were made in this country, but the most serious attempts were made in England and Russia, where the Imshenetzky process was used to make a board called uralite. It was the most satisfactory substitute for wood which had appeared up to that time. Uralite was composed of a sheet of asbestos millboard saturated with a solution of silicate of soda, which was subsequently precipitated as colloidal silica by a solution of bicarbonate of soda. For some reason not connected with the physical or chemical properties of the material, uralite has practically disappeared from the market. There have appeared from time to time a number of patents for boards composed mainly of fibers and lime, but no great use seems to have been made of them.

After much study two conclusions seemed inevitable to the author: First, no homogeneous inorganic substance was likely to prove satisfactory, but that a mixture of a fiber and a cementing substance was necessary to give wood characteristics to the material; and secondly, a mixture of asbestos fiber with one or two cements (first oxide of magnesium or calcined magnesia, and second calcium silicate and aluminate mixture) seemed more suitable than any other combination.

The author proceeds to describe what he calls asbestos wood made under his patents and developed from the application to mixtures of certain processes of mixing, pressing and curing. It is stated to be practically incombustible, harder than natural woods, to have a transverse strength about two-thirds that of white pine with the grain, and, without being brittle, an elasticity less than that of natural woods; the coefficient of thermal conductivity has been found in English units to be between 50 and 30 B.t.u. per sq. ft. per 24 hours, per 1 deg. fahr.

The weight of the several grades of asbestos wood 1 in. thick varies from 8 lb. to 13 lb. per sq. ft. White pine 1 in. thick when dry weighs approximately 3 lb. per sq. ft., and oak about twice as much. The transverse strength of boards and the maximum fiber stress is between the limits of 5,000 lb. and 10,000 lb. Test specimens 12 in. wide, 12 in. long and $\frac{1}{4}$ in. thick, broken by center load when supported on two edges with 11 in. span, broke on an average at 200 lb. load. Under the same conditions clear white pine broke under a load of 300 lb. with grain and 20 lb. across it. In some cases the equality of strength in both directions is of great advantage.

The tendency of the material to absorb water varies between the limits of 4 per cent and 20 per cent. This absorption is not of such a nature or amount as to cause disintegration from freezing and the material is not injured by prolonged soaking in fresh water. Sea water tends to disintegrate it after a time, the magnesium salts in the water replacing the calcium of the cement.

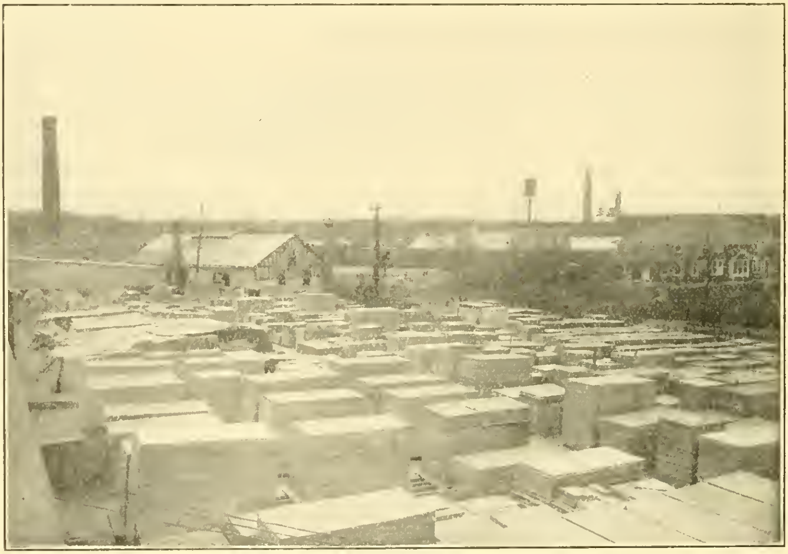

Fig. 1 Storage of Asbestos Wood

The coefficient of expansion varies with the temperature and also with the age of the specimen. It is small, being about 0.000004 at ordinary temperatures, diminishing rapidly at 700 deg. fahr. and becoming negative at 950 deg. fahr. where shrinkage occurs.

The operations of boring, sawing and finishing are all somewhat more difficult with asbestos wood than with the natural woods. It withstands scraping and rubbing much better. Floors and stair treads made of the material wear well, but are liable to be slippery when wet.

Many of the common wooden details of modern buildings have been successfully duplicated in asbestos wood, doors usually being hollow to save weight. Wherever there is danger of ignition of wooden framework a lining of the material has been found effective, notably in the vicinity of electric apparatus. It has been found best to mold the sheets while still in a plastic condition so as to form large pipes or ducts, and many locomotive round-houses have been equipped with smoke jacks or ventilating hoods. Shingles which have been in the weather for years have proved durable and this quality seems certain to equal that of fire resistance.

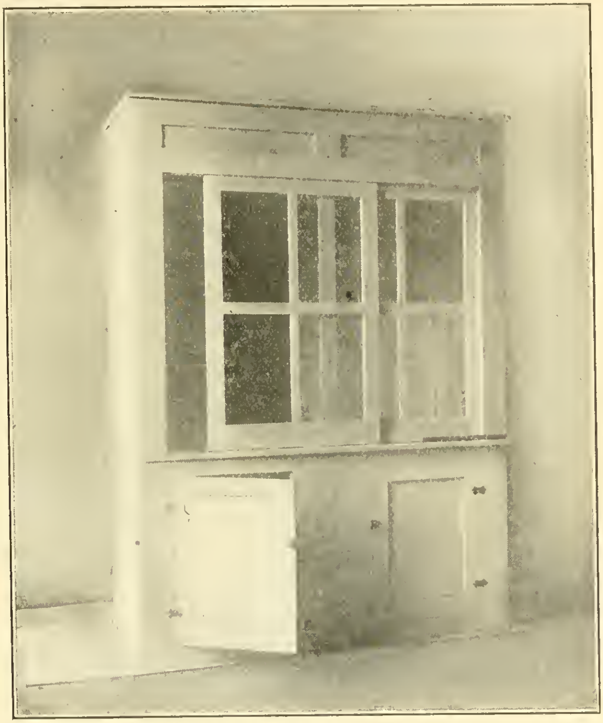

Fig. 2 Cabinet of Asbestos Wood

The ability to stand heat makes it available for blocks on friction brakes where a flexible material is not needed. The coefficient of friction of iron is approximately 0.3 to 0.4.

It has also been used as a mold for glass utensils during the process of manufacture, its non-conducting properties making it preferable to iron in some instances.

It is, of course, the fire resistance of the asbestos wood which gives it its greatest interest. There is nothing combustible in it, and on exposure to fire nothing can occur except a gradual dehydration of both fiber and cement. Under prolonged red heat the boards become weakened, but for such exposure as occurs in fires in buildings the resistance is ample. For instance, a sheet of $\frac{1}{4}$-in. asbestos wood may be placed over the top of an open furnace at 1700 deg. fahr., the flame impinging directly on the lower surface of the sheet, and at the end of half an hour the sheet may be taken off and while its lower side is still white hot be plunged into cold water and then returned to the furnace for 10 minutes. It may be slightly warped and its strength will probably be diminished 25 per cent or more, but it will still be sound and whole and free from cracks or serious weakness. Fire tests have shown the ability of the material to withstand much longer exposure, but it is not suitable for linings for furnaces or

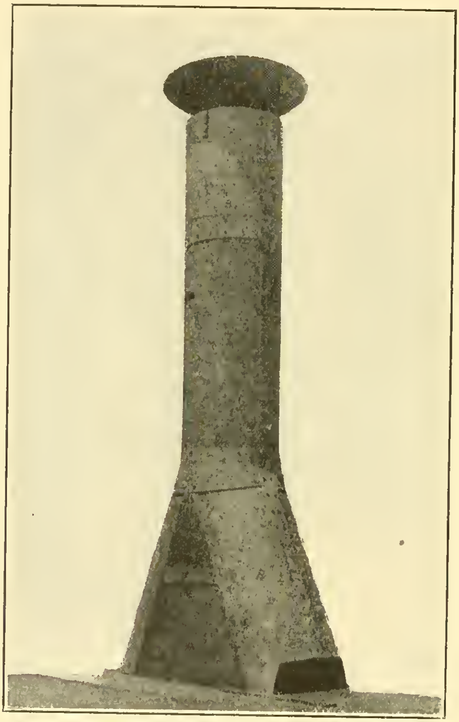

FIG. 3 STACK OF ASBESTOS WOOD

kilns which are kept constantly at red heat. In some fire tests the paint on the outside of an asbestos wood door 1¼ in. thick was not scorched after the fire inside had been burning at a temperature of 1700 deg. fahr. for more than an hour. Fig. 1 shows the method of storage of the material and Figs. 2 and 3 two of its applications.

DISCUSSION

In the discussion which followed the reading of the paper, F. E. Cabot[1] emphasized the general necessity of making more extensive use of fireproof material in building construction and considered the tin-clad fire-door, properly made, better than any other form of protection yet available. He would welcome the use of fireproof material especially for roofs and trimming.

W. L. Puffer[2] recently had occasion to have designed certain structures which were fireproof and on which he could have high potentials. Among other things tried was asbestos wood. The carpenter found that it was a good thing, but rather rough on tools; fastening it in place also proved difficult, because neither wood screws nor boring a hole and tapping it would do, and the block could be held in place only by cutting a groove along the edge and bolting it in. As a material for use in electrical work, asbestos wood will not handle the electric arc problem, although it will stop comparatively large flashes.

F. F. Jonsberg[3] advocated the use of fireproof construction from an investment point of view, but said that he generally had trouble in persuading architects to use either concrete or asbestos shingles, because they said they could not secure as artistic an effect as is possible with the usual materials.

F. A. Waldron pointed out that with the existing methods of enforcing the building law in some cities, the question of comparative cost of fireproof and non-fireproof construction was often the deciding argument, and he would like to have more data as to that.

H. F. Bryant[4] mentioned his experience with making doors of a refractory substance which he would not call by name; the doors were heavy, mechanically weak, and generally unsatisfactory.

L. S. Cowles[5] thought the question of cost, entirely neglected by Professor Norton, fully as worthy of scientific consideration as, for

[1] Engineer, Boston Board of Fire Underwriters, 55 Kilby St., Boston, Mass.

[2] Consulting Engineer, 201 Devonshire St., Boston, Mass.

[3] Contractor and Builder, Old South Building, Boston, Mass.

[4] Engineer, 334 Washington St., Brookline, Mass.

[5] Assistant Designing Engineer, Boston Ry. Co., 101 Milk St., Boston, Mass.

example, the method of combining and treating suitably the materials which made up the finished product.

F. B. Sanborn[1] wrote that wood served fairly well for fire-resisting purposes when properly embodied in building construction. For floors and roofs two elements were in favor of wood, cost and sufficiency, and, until further changes came about, there did not seem to be any reasonable way to check the present excessive construction of wooden buildings. There was, however, a great and growing demand for a fireproof material to be used for such special purposes as construction of heater rooms, furnace casings, smoke ventilators, and if asbestos board could be adapted to these purposes, there would certainly be an extensive demand for it.

E. V. French wrote that cases often arose where a fireproof building was desired quickly, or where conditions made the use of metal lath and plaster, otherwise satisfactory, inconvenient. A reliable substitute for wood which could be easily worked and which would give a durable and fire-resisting structure, would be of value in such instances. Corrugated iron was often used, but in case of an outside fire, heats through very quickly, and was not durable. It was desirable to appreciate, however, that incombustible construction did not make a fireproof building because in many cases there would inevitably be a great deal of burnable material in the contents, and such conditions could be made safe only by the use of automatic sprinklers.

L. H. Kunhardt emphasized the necessity of avoiding continuous hollow or concealed spaces in building construction, when fireproof material was nailed on to wooden posts or uprights in partitions, etc.

In his closing remarks Professor Norton stated, that although fire doors of large size break, he made doors, and they were growing in size. Asbestos wood required special although not very different treatment for use in switchboards, and had the advantage that even if very great heat drove out the insulating compound, the asbestos was left, and electric fittings stayed in place.

He also spoke of the series of thermal transmission tests being made with all building materials, concrete, wood, paper, carpets, etc., a good deal of the expense of which was being borne by the American Academy of Arts and Sciences. Professor Norton expressed the hope of being able to present the engineering features of this matter to the Society not later than next June.

[1] Professor Civil Engineering, Tufts College, Tufts College, Mass.

POWER SYSTEM OF THE PACIFIC MILLS

On October 18, a meeting was held in Boston under the auspices of the Boston Society of Civil Engineers, in which the Boston section of the American Institute of Electrical Engineers and The American Society of Mechanical Engineers coöperated. The paper of the meeting, by Fred A. Wallace, describes the power system recently installed to supply electric current for power and lighting to the cotton, worsted and printing departments of the Pacific Mills at Lawrence, Mass.[1]

The Pacific Mills Corporation operates several properties, the largest of which is the group of mills and works on the north side of the Merrimac River at Lawrence, Mass., motive power for which has in the past been obtained from a variety of steam engines supplemented by waterwheels. Recently a powerhouse with turbo-generators, concrete coal pocket, etc., has been provided, and an electric transmission system extending throughout the property. The paper includes a description of the plant, transmission system and motor drives, as well as of the methods and organization for operation and inspection, and considerable information as to costs. An interesting feature was the reference to a double walking beam Corliss steam engine, built in 1847, to take steam at 30 lb. gage, and running 30 r.p.m., which in its later years of service has been run on exhaust steam from other sources. This engine was purchased as a high-pressure, high-speed machine.

Under the old arrangement there were at the upper mill, two 28-in. by 48-in. Buckeye engines of 750 h.p. each connected to four waterwheels; also the old Corliss engine geared to four other vertical waterwheels. The jackshaft of both sets of waterwheels was connected by belt transmission through the several floors of the seven-story mill to different departments and by long lines of shafting and gearing to the print works.

The displacing of these belts and shafts by electrical transmission made room for much extra machinery, besides improving general conditions of cleanliness and fire risks. A great many sets of large bevel and spur gears were also removed by this change, which increased the general efficiency, as well as eliminated a great deal of noise and mechanical troubles.

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[1] Published in abstract only. Complete report may be consulted in the rooms of the Society.

A Rice and Sargent cross-compound 800-h.p. engine was removed from the lower mill, and this load as well as a large overload from the remainder of the power system was transferred to the new central station. The Corliss engine, designed over 60 years ago, was also torn down. This engine had two vertical cylinders 38 in. by 84 in., both operating condensing. The flywheel was a gear 20 ft. in diameter and 18 in. face, driving a pinion on the waterwheel jackshaft. In general appearance it was like the famous "Centennial Corliss," but not so elaborately finished. It was built by Nightingale, Bancroft & Company, of Providence, R. I., and was one of the first engines in which George H. Corliss was interested. It was made before the Corliss rotary cut-off valve was introduced, and the speed was controlled by a throttling governor.

In 1897 this engine was overhauled and the valves adjusted to run on low-pressure steam, which was taken from an exhaust system into which nearly 100 engines and pumps of various sizes exhausted. Enough of this exhaust steam was used by the engine to produce about 350 h.p. and the remainder was used for manufacturing purposes. This engine was one of the first large power units to run on exhaust steam.

No tests were made to determine the economy of this arrangement, but it must have been good under the conditions. In changing the engine to run at low pressure and with high vacuum it was realized that there is as much energy given up by 1 lb. of steam expanding from 0 lb. gage pressure to 27 in. vacuum as when expanded from 150 lb. to 0 lb. gage. This shows the great energy stored in steam at low pressures, but which cannot be utilized with a cylinder and piston on account of prohibitive proportions. This is the field now being taken by the low-pressure turbine, which promises to make great improvements in economical power generation. Recent tests indicate that the turbine is making the largest gains in economy since the great changes brought about by the Corliss valve and the expansive use of steam.

In place of the earlier miscellaneous power equipment, it was decided to build a central power plant, which is one of the largest isolated steam-turbine stations devoted entirely to the textile industry, and to adopt electrical transmission. The water power is used in connection with the power from this central station, the wheels being connected to generators which run in parallel with the rest of the system. The water power is developed in two places, east and west wheel pits, each having two 39-in. and two 36-in. Hercules wheels, direct-connected to generators. That for the east pit is 800 kw. capacity and for the west pit, 600 kw. Although there are four wheels connected to each of the generators, it is customary to run only two, except in times of high back water. The marked advantage of this system is that the power can be supplied to any department for overtime work, as water can be used 16 hours a day without extra cost.

The new power station is located on a $3\frac{1}{3}$-acre lot adjacent to the main line tracks of the Boston & Maine Railroad, about $\frac{1}{4}$ mile from the upper mill, and sends current at 2300 volts to four centers of distribution, the farthest of which is over $\frac{2}{3}$ mile away.

The plant consists of a building for the boiler and turbine room, and a separate coal pocket. In the boiler room are twenty-four 72-in. by 21-ft. 6-in. horizontal, multitubular boilers, arranged in six batteries of four boilers each, 12 boilers being on each side of the firing floor. This floor space is 24 ft. wide, and on a level with the yard and the turbine room basement.

Steam leaves each boiler by a 4-in. pipe, and passes through Foster superheaters set in the rear of the combustion chamber, before entering the main line for distribution. All are connected to a 10-in. main steam header from which steam passes to the different turbines and auxiliaries.

An ingenious arrangement for supporting the steam header is that of a steel-yard arm held at the ceiling, and carrying weights to balance the load of the pipe and fittings. The piping was installed in place with all its fittings, but not connected to the boilers. The weights were moved exactly to balance the entire system, some levers requiring much more than others. When adjusted, the branches were all bolted to the boilers, and the entire line was supported without any strain.

In order to secure the highest efficiency from the superheat, the steam travels through the piping at an average velocity of 7900 ft. per min. The turbines are supplied with steam at 150 lb. boiler pressure, 125 deg. superheat.

Feedwater is furnished by duplex steam pumps from the condenser discharge, at about 75 deg. fahr., through an exhaust steam heater which raises the temperature to about 200 deg. fahr. This heater condenses the exhaust steam from the auxiliaries of the station.

Each group of 12 boilers has a chimney 9 ft. inside diameter by 200 ft. high, built of common red brick. Each chimney is constructed with a separate red brick core wall, which takes the heat of the gases, and allows for expansion and contraction.

The turbine room is equipped with Allis-Chalmers steam-turbine generating sets, and as the station now stands it contains two 3250-kw. and two 750-kw. steam turbines with jet condensing outfits; two motor-driven exciter sets; one steam-driven exciter set, and one 75-kw. engine-driven alternator, with exciter. A small motor-driven centrifugal pump furnishes all pressure water for the station.

Under the turbine room is the basement, containing all the boiler-feed pumps, condenser apparatus, fire pumps, heaters, etc.; and below the basement is a cistern connected to the river, about 1000 ft. distant by a 48-in. penstock. This well supplies water for condensing and all other uses about the station. The condensing water is raised in temperature from 15 to 20 deg. fahr. in passing through the jet condensers, and is then returned to the river through a conduit. The river water is nearly 32 deg. during the several months of the winter and reaches a maximum of 85 deg. in the summer.

The air for cooling the turbo-generators is supplied through a shaft extending above the roof, next to the chimney. The dirt is filtered out by a series of 12 bags of cotton cloth. These bags are cleaned every three months, and about 6 quarts of dust is collected containing considerable carbon, evidently from passing locomotives. The small quantity is probably on account of the height of the entrance from the street.

The current is sent from the station at 2300 volts through lead-sheathed cables, in vitreous conduits underground to four main divisions: (*a*) upper mill power and light; (*b*) yarn mill lighting; (*c*) lower mill power and light; (*d*) the new worsted power and lighting.

The current is stepped down as required for use in the different departments, but in the new worsted mill all are 2300-volt motors. The current from the waterwheel generators is transmitted at 550 volts. The 75-kw. alternator mentioned in the turbine room is used for supplying the current for the yard lights, which are on all night, and for other small uses. A separate transmission circuit was installed for this set, in order to avoid using the large transformers.

The following figures are for cost of operating, an average week, on 3600 kw. These are the conditions under which we have been operating for the last year:

Turbine room labor, 5 men and superintendence	$99.85
Boiler room labor, 8 men	99.15
Fuel at $4.25 per long ton, in pocket	880.00
Oil, waste, supplies and repairs	37.05
Total operating expenses per week	$1116.05

During the week, 204,780 kw-hr. are generated, giving a cost, per kw-hr., of 0.545 cents. The load will soon be increased, due to putting all of the new worsted mill into service, and there will be required approximately 340,000 kw-hr. per week. The normal operating condition will then be to run the two large turbines, leaving the two smaller ones as spares. To operate the station under these conditions will cost:

Turbine room labor, 5 men and superintendence	$ 99.85
Boiler room labor, 9 men	108.95
Fuel at $4.25 per long ton, in pocket	1483.25
Repairs and supplies	58.60
Total operating expenses per week	$1750.65

Operating cost per kw-hr. equals 0.515 cents. The station as it now stands, 8000 kw. normal capacity of generators, costs, with land and everything, up to and including the switchboard, a little less than $90 per kw. Figuring the fixed charges on this at 11 per cent, we get 11 per cent × 720,000 = $79,200 per year, or $1523.08 per week, and 1523.08 divided by 340,000 equals 0.448 per kw-hr.

The total cost, then, per kw-hr. at the switchboard for the 6100 kw. load on the plant would be

Operating expenses per kw-hr.	0.515 cents
Fixed charges per kw-hr.	0.448 cents
	0.963 cents

The same figures, if this plant should be operated at its full capacity of 8000 kw., as is quite customary in textile mills, would be

Operating charges per kw-hr.	0.501 cents
Fixed charges per kw-hr.	0.340 cents
	0.841 cents

Analyzing these costs for the operating conditions of 6100 kw., it is found that a percentage of the total cost of

	Per Cent
Labor	6.4
Fuel	45.5
Repairs and supplies	1.8
Fixed charges	46.3

These figures show plainly that less fixed charges and better fuel economy are the items which may result in a considerable saving. While economies might be effected by more expensive and efficient apparatus, it must be remembered that the more complicated apparatus invariably requires more expense of repairs and depreciation. The principal object in view in the design and operation of this installation has been simplicity and reliability. Many of the requirements supposed to make for refinements in efficiency have been omitted.

There is still some engine power and pulley and belt transmission used in the plant, which is gradually being superseded by electric power. When the old mills were changed from engine to motor drives a great amount of shafting and belting was removed, and this in itself is one of the motor's best recommendations, not mentioning the flexibility of service, ability to check power required at any time, increased production due to uniform speed. We have, however, no accurate way of knowing whether the total power of the mill is more or less with the electric driving than with the old system, as a great deal of the textile machinery was changed at the same time as the power system.

ELECTRIC PROPULSION OF SHIPS

At the meeting of the Society held in Boston on December 20, 1911, with the Boston Society of Civil Engineers and the Boston Section of the American Institute of Electrical Engineers, W. L. R. Emmet gave a talk on Electric Propulsion of Ships.[1]

Many persons familiar with turbines and modern turbine development are not familiar with ships; many of the people familiar with turbines are not familiar with large turbines; and many of both classes are not familiar with electricity. Hardly anybody but the author and about two people in England have really come out as advocates of the electrical propulsion of ships. Mr. Mavor [2] has devised many schemes for electrical propulsion and has brought forth very many fruitful facts about it and aroused considerable interest; but generally speaking the electrical propulsion of ships has attracted no great attention and has at present very few advocates; this is largely to be attributed, in the author's opinion, to lack of knowledge of the matter, as well as to the fact that shipbuilders all over the world are unfriendly to electric propulsion, presumably because it robs them of the building of the engines.

The large marine engines of today are limited in many ways by the dimensions and practicabilities of the case, valve areas, cylinder volumes, etc., so that it is not uncommon to find that in ships the largest engines are not the best. In the application of electric generators with turbines exactly the reverse is the case. The largest unit is the best within the desirable limit of speed, and the only limit to the size of the turbine is the size of parts which can be handled and shipped; and as the size goes up, the efficiency improves, and weight and cost per horsepower diminish. When applied to small vessels the comparison of electric propulsion with other methods is not very attractive, but becomes wonderfully so in large vessels.

After considerable trouble the General Electric Company obtained from the United States Government an award to equip with electric propulsion the collier Jupiter, a ship of about 20,000 tons, giving 14 knots, and now being built at the Mare Island Navy Yard. Even such a ship is only moderately adapted to electric propulsion, for the reason that the power required in it is not large enough to make the best relative showing. Electric propulsion is really well adapted to very large vessels, particularly those of moderate speed to which the turbines are not directly applicable.

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[1] Published in abstract only. Complete report may be consulted in the rooms of the Society.

[2] Glasgow, Scotland.

The author proceeds to compare the collier Jupiter with its sister ships, Cyclops and Neptune, the former of which was equipped with marine steam engines and the latter with a steam turbine and reduction gearing, and shows that even in such a vessel electric propulsion has important advantages. The collier Cyclops, built by Cramps and equipped with very fine triple expansion engines, required about 6800 shaft horsepower to make 14 knots, and her engines weigh 335 tons, not including the weight of galleries and structures. An equivalent equipment on the Jupiter has an overall weight of only 145 tons, and besides takes up very little room. The author does not know the steam consumption of the Cyclops, but takes it to be 14½ lb., which is extremely good for this class of vessel, while the equipment on the Jupiter, basing the calculation upon a generating unit which has already been run and tested under similar conditions, will deliver 12 lb., giving at least 2½ lb. better economy. Furthermore, this equipment is ideally simple and compact. It is the simplest form of electrical transmission which is known, and it possesses the advantage that in this case the power is not taken from a great reservoir of power, but just as much electricity is made as needed, and the generator is at no time capable of delivering, even on a short circuit, very much more current than ordinarily passes to the motor. The voltage is low and the windings are of the simplest type.

The collier Neptune was recently run with turbines and gearing. The gearing worked successfully, as the author understood, but for some reason the turbines were run at low speed and the propellers at high speed, higher than they should, with a very poor result in economy. The Cyclops made in her trials 14.6 knots with the propeller running about 94 r.p.m., while the Neptune made 12.9 knots with the propeller running about 135 r.p.m. The author thinks that the fault lies in an unsuitable selection of speed, and that better results may be obtained with other turbines and different propellers, but that the results will never be as good as with electric propulsion.

The application of the turbine itself to marine propulsion, while it has an enormous field, is a difficult matter, because the turbine is seriously handicapped by the necessities of propeller speed, and it is only in the very largest and fastest vessels that the turbine finds a good application. In a vessel like the Lusitania the speed of the ship is so great that she can run at a very high propeller speed with fair efficiency, and consequently her turbines, on account of their enormous size, are at a pretty nearly desirable speed. Since the propulsive coefficients of many of our large turbine-driven battleships are below 50 per cent, that is, the ratio of power delivered to the propellers to the power which would have to be delivered to a tow-line to pull that ship through the water. The losses which concern us in electrical processes are very small in comparison with these great inefficiencies of the propeller, so that we cannot change the propeller speed much without risk of losing all the advantages of whatever we are using.

The author considers the Jupiter turbine the highest development of the Curtis turbine to date. It is carried through one very high-speed stage down pretty well in pressure. There is something like 80,000 ft-lb. of work in this stage. From there on there is a continuous admission. Another feature of this machine is that every bucket is accessible, so that the top can be taken off, the nozzle parts removed, and any bucket can be taken out and replaced without taking the shaft out of the turbine. There is an upward steam delivery which connects up to the condenser. This unit is equipped with a governor designed with a characteristic very different from that ordinarily used in speed governors. It is designed so that by a certain setting of the levers connecting from the governor to the valve operating mechanism, the governor can be made to control the speed at any point from full speed down to something less than one-quarter speed, and it will hold it within 1 or 2 per cent no matter how the wind blows. Furthermore, there is an arrangement entirely apart from this engine adjustment, by which the speed control dial can be moved by electrical action from the bridge.

The Jupiter motors are simple induction motors of low voltage, of what would be called M-type, having collector rings and brushes by which a resistance can be put into the circuit of the rotor. Normally a slider short-circuits the collector rings, so that the motor is closed upon itself, and there is no current passing in the collector rings. There is an external resistance which, when this slider is withdrawn, is in the circuit, and the introduction of that resistance gives the power of exerting a high torque irrespective of the speed of the motor, as well as a large reversing torque. Under these conditions the amount of energy delivered to the resistance is very large. The author has devised a novel resistance for that purpose. In very large ships no changes of connection would be made when the circuit is alive. The field of the generator would be opened and the circuit killed before changing the connections, and all these would be interlinked by magnets so that the field could not be moved. In ships of the size of Jupiter it is easy to change the circuit while alive, with no fear of endangering any of the contacts.

Whenever the question of electrical propulsion is mentioned, propulsion by gearing naturally invites comparison. The latter is as yet merely problematic, because nobody knows yet what the safe limits of application of high-speed gearing are. There are, however, very good reasons for supposing that gearing is not the best method of propulsion for very large ships. There is at present one ship, the Vespasian, being successfully propelled by gearing, the equipment of which was designed by Sir Charles Parsons. The Vespasian is a vessel of one propeller, about 10 or 11 knots, with propeller speed of about 75 r.p.m. The turbines are divided into two parts, and the larger gear is driven with two pinions. These pinions are only about 5 in. in diameter. The large gear is about 8 ft. in diameter, so that the speed reduction is 20 to 1. Each of the two pairs of pinions delivers only 500 h.p.

This gear has worked and has given a very fair showing; it has given a somewhat better efficiency on the Vespasian than an engine could give her, but it would be a very different thing to apply the same method to a ship where one has to deliver 17,000 h.p. instead of 1000. Should we apply more power to one of these double pinions 2 ft. long, the torsion of that long bar would be sufficient to give the whole bearing on one end of one of these pinions. It would not distribute itself, and so we are limited in power by the stiffness of the pinion shaft and the pinion itself. It must be rigid, because if it twists a little, the teeth do not engage properly. Therefore to put more power in it, to make it stiffer, its diameter has to be increased, and to keep down the pressure on the teeth, the length must be increased. But as soon as we increase the diameter, we have to decrease the turbine or the propeller speed or increase the diameter of the large wheel, which is already 8 ft., and that involves a further difficulty of maintaining a perfect working position between centres many feet apart in the ship. The difficulties of high-speed gearing increase with the size, like a gas engine, and if any is distorted, even the very slightest degree, there will be a blow like that of a projectile striking an armor plate. Until some improved method of running gearing is adopted, the propulsion of the 1000-h.p. Vespasian means nothing in connection with the question of the propulsion of steamships on trans-Atlantic lines, while in the Neptune the propeller speeds are far too high, and the turbine speeds far too low. In the electric propulsion of the Jupiter the speed used on the turbine is 2000 r.p.m., and there are two propellers running at a speed of 110 r.p.m., which was the speed selected by the officers of the Navy Department as the most desirable, so that both the propellers and the turbines are driven at the best speed.

The talk was illustrated by numerous slides.

DISCUSSION

In the discussion which followed, Prof. Ira N. Hollis described the use of gearing in a ship on a large scale as early as 1866. It was a ship designed originally to catch the Alabama. The reason for putting the gearing in was the desire to drive the propeller at 75 r.p.m. by a reciprocating engine of low speed making 30 r.p.m. The ship was tried and run for 36 hours at full speed, with the result that the gear was too much worn to be thought reliable in a sea afterward. Gearing is made a great deal better now, but Professor Hollis stated that nevertheless he has comparatively little faith in the results.

Prof. C. H. Peabody[1] pointed out that until somebody invents an entirely different method of propulsion, the coefficient must be low, as the efficiency of the propeller is between 65 and 70 per cent, and this is due to the fact that it is necessary to have some form of propeller entirely external to the ship.

Mr. Emmet finally stated that the frequency used in the apparatus varies in different cases. In the case of the battleships the maximum frequency is about 40 cycles, in the collier Jupiter about 33 cycles, and a little below 30 in the other large vessels of which Mr. Emmet spoke, but the frequency diminishes with the speed, the turbine slowing down with the ship. The whole subject of electric ship propulsion is very much limited by the matter of frequency, for the reason that a generator cannot be built with less than two poles. If generators could be made with

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[1] Professor Naval Architecture and Marine Engineering, Mass. Inst. Tech., Boston, Mass.

1 or $1\frac{1}{2}$ poles, slower ships could be driven effectively by electricity, but the difficulty is that high frequencies cannot be used, because with slow propellers an impracticable number of poles in the motors results. Very low frequencies must be used, and this is not possible with high speed in the turbines, because the least number of poles is two. That is one of the principal reasons why electrical propulsion finds its best application in large ships.

NEW HAVEN MEETING

COST OF POWER WITH SMALL UNITS OF VARIOUS TYPES

At a meeting held in the Mason Laboratory, Sheffield Scientific School, New Haven, November 15, 1911, which was the first meeting of the Society in that city, the subject for discussion was the Comparative Cost of Power.[1] The Chairman of the meeting was E. S. Cooley, and several engineers from New York, Hartford and other cities were in attendance, including President E. D. Meier. This meeting has already had a brief notice in The Journal for December 1911.

The first paper on A Small Producer Gas Power Plant in a Wood-Working Shop, by Albert W. Honywill, Jr., gave the cost of operation and working conditions, with a producer plant installed at the Lampson Lumber Company of New Haven. The engine is rated at 45 h.p. at 160 r.p.m. and is of the four-cycle hit-and-miss type, with poppet valves and jump-spark ignition. The producer is of the ordinary suction type, with stationary grates, and the quantity of gas delivered to the engine is varied by a hand-adjusted throttle valve in the delivery pipe. The plant is in operation 9 hours a day, the engine kept running noon hour, and the load variable.

The average coal consumption is approximately 467 lb. of pea anthracite per day, or 46.7 lb. per hour. Assuming an average load factor for the shop of approximately 40 per cent, this is equivalent to $2\frac{1}{2}$ lb. of coal per h.p-hr. The cost of coal delivered is $4.50 per ton, which would give an average cost per b.h.p. per hour of 0.56 cents. No account is taken of the cost of water, as the only cost is that of pumping.

The first cost of the plant, including producer, engine, blower and motor to drive same, was, in round figures, $3500. The operating expenses per day were found to be:

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[1] Published in abstract only. Complete report may be consulted in the rooms of the Society.

Coal, 467 lb. at $4.50 per ton	$1.05
Labor	2.50
Repairs and depreciation	1.16
Interest and taxes	0.70
Oil and waste	0.14
	$5.55

The ashes from the producer were, however, screened, and coal secured in this manner may be estimated at $2 per ton, which reduces the real operating expenses to $5.08 per day.

Following the paper by Mr. Honywill, there was a brief discussion, after which a paper was read by E. H. Lockwood, joint author with F. P. Pfleghar[1] on Comparative Cost of Power by an Oil Engine and a Steam Engine. The cost of power of the following engines was compared: A De La Vergne oil engine, horizontal, single-acting, center crank, four-stroke cycle, jacket water-cooled; fuel, petroleum fuel oil at about 3 cents per gal. at the factory; ignition, hot chamber, on the Hornsby-Akroyd system; cylinder dimensions, diameter 27 in., stroke 33 in., rated horsepower 125, used to drive a direct-connected 220-volt generator, the power being used for light and power, and average output being about 90 h.p. The engine was carefully tested for output and fuel consumption and was found to be quite economical of fuel. The steam engine was a horizontal 100-h.p. Putnam engine, and a Fitzgibbons boiler of the same rated boiler horsepower.

ACTUAL COST OF OPERATION OF OIL ENGINE

Fuel oil, 14 gal. per day	$3.78
Labor, half-time of one man	1.50
Oil, waste, water, repairs, per day	1.00
Cost per day	$6.28

Reduced to the basis of 300 days per year, and divided by 90 (h.p.), the above cost amounts to $20.93 per h.p. per year.

FIXED CHARGES FOR SAME ENGINE

Cost of engine and generator, 10 per cent of $6000	$600.00
Cost of heating boiler, 10 per cent of $1000	100.00
Insurance, taxes, etc., per year	250.00
Total fixed charges per year	$950.00
Fixed charges per year per h.p.	$10.55

Combining the two costs, the total cost per h.p. per year, operation and fixed charges, is $30.48.

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[1] President Pfleghar Hdw. Spec. Co., New Haven.

ESTIMATED COST OF OPERATION OF STEAM ENGINE

Fuel per day, $2\frac{1}{4}$ tons	$8.21
Labor, time of one man	3.00
Oil, waste, etc., per day	0.50
Total per day	$11.71

Reduced to the basis of 300 days, and divided by 90 (h.p.), the above cost amounts to $39.04 per h.p. per year.

FIXED CHARGES FOR SAME ENGINE

Cost of steam engine and generator, 10 per cent	$350.00
Cost of boiler, 10 per cent	200.00
Repairs, insurance, and taxes	250.00
Total fixed charges per year	$800.00
Fixed charges per year per h.p.	8.88

The two costs combined give a total cost of 1 h.p. per year, operation and fixed charges, of $47.92.

This showing is favorable to the oil engine, but it must be remembered that the steam engine has a useful by-product of exhaust steam during seven months of the year when the factory must be heated. Allowance can be made for the steam used in this way by deducting the cost of coal required for heating, which, estimated at 1 ton per day on the average for seven months, is about $766. By this credit the cost of power by the steam engine is reduced, but is still above the oil engine, as will be shown by the following summary:

Total cost of power by 90-h.p. oil engine, including labor, fuel, fixed charges, etc.	$30.48
Total cost of power by 90-h.p. steam engine, including labor, fuel, fixed charges, etc., and giving credit for exhaust steam for heating	39.38

Both the above are on the basis of 1 h.p. per day of 10 hours, 300 days per year.

Following the paper by E. H. Lockwood, there was a discussion, after which a paper was read on The Status of Small Steam Turbines by W. J. A. London. He considered that the question of water rate does not cover the real meaning of efficiency; in a small turbine a difference of a few per cent in water rate efficiency means comparatively little as far as the cost of operation is concerned, and if higher water rate efficiency may be attained only at the cost of additional complication and weight, and higher first cost, he thought it would be a mistake always to prefer absolute water rate to commercial efficiency and especially reliability of operation. As regards the actual water rates obtained, the turbine is not a "steam hog," as shown by a few examples quoted below, but the engineer in practice is more interested in his overall water rate per air, electrical or water horsepower, as the case may be, and in this respect units are now obtainable which can hold their own against all competition, not only in reliability but in actual water rate efficiency. In general, however, where a guarantee made by the turbine builder apparently falls down in actual tests with a blower or pump, it is often found that the fault lies with the pump rather than with the turbine. With regard to the comparative performances of turbine-driven and engine-driven pumps for boiler-feed purposes, some interesting comparisons (Table 1) are obtainable from the tests made on board the scout cruisers Birmingham, Chester and Salem. Together with these figures are given the water rates that are obtainable from the modern turbine boiler-feed pump.

TABLE 1 PERFORMANCE OF RECIPROCATING FEED PUMPS ON SCOUT CRUISERS AND EQUIVALENT PERFORMANCE OF TURBINE DRIVEN SETS

	Steam Pressure, Lb.	Back Pressure, Lb.	Gal. per Min.	Ft.	Water Rate	Equivalent Turbine Water Rate	Improvement, Per Cent
Birmingham...	183	6	329	488	83.0	61.8	25.5
Salem.........	203	6	193	690	91.8	61.2	33.6
Chester.......	187	6.7	219	610	101.0	64.0	34.6
Average....	....	....	....	....	91.9	62.4	31.2

On reciprocating sets efficiency assumed: pump—85 per cent, engine—90 per cent.

On the general subject of steam consumption of small steam turbines, the writer thinks that Napier's formula might be used to greater commercial advantage than it is at the present time. The majority of small turbines now operate with a terminal pressure at the jet below 0.58 of the initial pressure, so that this formula can be applied to any machine, and the steam consumption determined by placing a gage in the steam ring, the number and size of jets being known. In a series of tests carried out within the last few days, in seven readings with a ring pressure varying from 40 to 150 lb., the maximum discrepancy between calculated and actual results was 1.3 per cent and the mean over all the readings was 0.443 per cent.

The design of the machine should be as simple and the governor and other mechanism attached thereto as fool-proof as possible, even at the expense of efficiency, if necessary, and recent government tests have shown that the single governor mounted directly on the turbine shaft is sufficiently sensitive for close regulation.

DISCUSSION

In the discussion of these papers Alexis Krah,[1] of New Haven, Conn., said that the bad features of the oil engine are the necessity of heating it up for about 20 minutes before it starts, the expense of frequent renewals of caps, irregular work of the generator when directly connected on the shaft, and higher expenses for keeping up the engine. The engine generally gives more trouble than a steam engine, and in winter is less economical.

Geo. A. Orrok, answering A. D. Risteen's [2] question, said that very little nickel alloys have been used in gas engine construction, and, although in Germany cylinders are made of iron in which the coefficient of expansion is remarkably small, such castings are not. produced in this country.

A. E. Greene, of Hartford, Conn., pointed out that whatever source of power as a prime mover we have, we find it necessary to use coal for heating purposes, and one cannot say that one type of prime mover will be satisfactory for all conditions. In New England steam engines seem to give very good satisfaction if all-year efficiency is considered.

W. S. Huson explained the system in use along the canal of the Housatonic River for selling water power by the square foot, and gave the cost of 11 sq. ft., 110 h.p. per year, as $2550.

In discussing the question of efficiency, Mr. Orrok pointed out that his company has about 40 small turbines in service, the oldest ones being five years old, and that as yet not a cent was spent for repairs on them; all the attention they get is that of a man putting his hand on the bearings, once or twice a watch, to see that they are not warm. As regards the water rate of feed pumps, the feed pumps are run at from 0 to 50 per cent of what they can do, and under these conditions cannot be efficient, and do not have to be; if by using a small turbine, the pump can be made simpler and more reliable, that is all that is required.

The chairman called attention to the fact that with a small turbine, even if an accident does occur, due to some fault in installation, it does not have such serious consequences as in the case of a steam engine, and C. H. Norris added that the turbine seems to be the apparatus that would serve best under abuse in backward plants with poor engineers. L. P. Breckenridge invited the members to send to the Secretary any specific information they may be able to furnish as regards the cost of power in this locality.

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[1] M. M. Pfleghar Hdw. Spec. Co., New Haven.

[2] M. E., Hartford Steam Boiler Insp. & Ins. Co.

EVENING SESSION

In the evening session, Professor Breckenridge presiding, the president of The American Society of Mechanical Engineers, Col. E. D. Meier, addressed the meeting, telling how the first national society was formed of civil engineers, the engineers of the time; how, with the growth and differentiation of the engineering profession, other national societies were formed, until it seems that now is the time to put a stop to that movement by coöperation. The American Society of Mechanical Engineers is trying to accomplish this by the making of branches, groups or sections in various states, by granting them full autonomy, and by allowing the different sections to call in affiliates. This policy, as President Meier had occasion to see personally in Providence and several places in the West, appears to work very satisfactorily. The sections can do important local work in bringing together the members of the Society with men who may or may not be able to join the parent Society, but may be of use to it as affiliates. The production of papers by the local sections is also a valuable aid to the Society as a whole, and the Society has arranged to help its branches by printing for them at cost papers of local interest, the idea being to benefit not one particular society, but the engineering profession as a whole. In connection with that, President Meier called attention to the proposed celebration of the opening of the Panama Canal, the greatest feat of engineering ever performed by man.

After that Prof. C. F. Scott presented a paper, on The History and Development of the Hartford Electric Light Company. The Hartford plant has welcomed new things, and has always been ready for the opportunity to try new inventions. Professor Scott illustrated by numerous slides how the Hartford plant, always in the lead as to the choice of its mechanical and electrical equipment, has created a central station service supplying one of the busiest manufacturing centers in the country with light, and to a very large extent with power, cheaper and better than the plants could produce themselves.

The chairman then gave a brief history and description of the Mason Laboratory where the meeting was being held.

FACTORY CONSTRUCTION AND ARRANGEMENT[1]

By L. P. Alford and H. C. Farrell, Published in The Journal for October 1911

ABSTRACT OF PAPER

The arrangement and construction of the reinforced concrete factory buildings of the United Shoe Machinery Company at Beverly, Mass., are presented, with reference to their adaptability to the manufacture of light machinery. The advantages and disadvantages of concrete floors are discussed, and the experience of this plant given to show that such floors are satisfactory in the machine shop. The original manufacturing scheme, the one-shop plan, is described, together with the modifications that it has undergone since its inception. The original artificial lighting installation is shown with changes now being made to use the more recently developed higher efficiency lighting units. As the plant has had rapid growth, modifications based on experience have been made as new construction was undertaken, and these changes are traced in detail. Finally, the plant contains one of the first extensive developments in the use of steel storage racks. The design of these is given, together with an account of the conditions under which they were developed and the uniformly successful results in their use are shown.

DISCUSSION

Alexander Taylor (written). In 1885 the Westinghouse Electric & Manufacturing Company had grown to a size sufficient to warrant its occupying the entire set of buildings hitherto shared with the other Westinghouse companies. The buildings could hardly be considered modern, even for those days, and this, together with the fact that the company was constantly extending its lines of apparatus, made it practically impossible to work out in detail any fixed plan of manufacture which would prove equally suitable for all of its products. Following the usual custom of most small and even medium sized manufacturing concerns, the one-shop plan was adopted and an attempt made to arrange the equipment to group together similar machining and other operations, such as planing, drilling, milling, screw machine work, winding, insulating, baking, etc.

[1] Published in abstract only. Complete report may be consulted in the rooms of the Society.

Presented at the New York meeting, October 1911 of The American Society of Mechanical Engineers. All discussion is subject to revision.

This plan has the following advantages:

a For each of the principal operations, there is generally but one expert, and if the limited talent is to be used to the best advantage, no other scheme, such as the output department plan in which the equipment is arranged on the basis of product or output, is permissible.

b The centralization or localization of all equipment of a like kind, tends toward a decrease in the amount necessary for a given volume of work.

c Floor space will be economized.

d Conditions for obtaining best results in accuracy and speed of workmanship will be more nearly approached.

e Uniformity in methods will prevail.

f There will be a minimum distribution of power, etc.

Certain operations in the works paralleled themselves in one or more places, thus approaching to a limited extent the so-called output department plan, and until $3\frac{1}{2}$ years ago conditions were met fairly satisfactorily along lines which may best be described as departmentalization, partly on the basis of equipment and partly on the basis of product or output; or, to describe it in other terms, partly on the one-shop plan and partly on the output department plan.

In a growing concern manufacturing a diversity of product, a time eventually comes when the advantages of the one-shop plan are more than outweighed by other features which enter in and which must be given full consideration. One of the most apparent weaknesses of such a scheme is the increasing inability to fill orders with reasonable dispatch, and this is not confined to special apparatus which requires to be built from the ground up; but, it applies as well to fairly standard apparatus, the more so when the parts are not, for one reason or another, carried in stock. Evidence of this may be seen in the larger and larger number of rush, forfeiture and other special orders being placed in the personally conducted class to be given right of way and railroaded through the shops, regardless of the orders of less fortunate customers, not to mention orders for stock. This method of handling is not a solution of a difficult situation, but rather a makeshift and a course which if followed a sufficient length of time simply adds to the general confusion. Other equally grave defects are the multiplicity of foremen and superintendents concerned in the manufacture of any single class of product, the increase of clerical and of manual labor due to the volume of semi-finished and finished parts passing between "feeder" sections and from "feeder" to "assembly" sections, and, most vitally of all, the matter of divided responsibility. All of these features result in delays and in increased expenses of various kinds, which cannot be overcome; and it needs but little imagination to conclude that work in progress as well as stocks, raw and finished, will under such a scheme be high and that costs must follow suit.

As a result therefore of study in more or less detail of the plans followed by other large manufacturing companies, the management decided to divide the plant into separate manufacturing units, as self-contained and as independent of one another as the nature of the product of each would permit, believing that without sacrificing any of the essential advantages of the original plan, the difficulties incident to its later working could be largely eliminated and the following features still secured: (*a*) centralization of authority in the production of each class of apparatus; (*b*) decrease in time required to fill customers' orders; (*c*) increase in output in a given period; (*d*) decrease in work in progress and in stocks, raw and finished; (*e*) saving of floor space; (*f*) decrease in handling of materials; (*g*) decrease in clerical labor; (*h*) decrease in indirect expense or overhead burden; (*i*) increase in individual initiative; (*j*) healthy competition between similar sections and departments.

As a matter of caution it was decided to put the proposed plan into effect in but a single department, giving it a thorough try-out on a limited scale. The department embracing the manufacture of railway, mining and crane motors was selected for trial and divided into six sections: field machining, armature building, commutator and brush holders, armature winding, bearings and housings, motor assembling. The equipment was rearranged as well as increased either by the addition of tools from other departments where certain of the parts had previously been made, or by the purchase of new tools. In each of the sections named it was the aim, while grouping the tools together as much as possible according to similar operations, to prevent either a retraverse of the work or too great a traverse. The clerical and accounting features were also changed in keeping with the requirements, so that it would at any and all times be possible to measure within close limits of accuracy the relative advantages and disadvantages of the new move. The most gratifying results were obtained almost from the very start, and nothing subsequently developed to alter the first favorable impressions. Comparing the routine in this department under the original and the modified plans, where formerly the work was performed by no less than 22 sections located in 13 independent departments, it is now done by 13 sections in 7 independent departments. Under the modified plan, authority for the entire line of product was vested in a single individual, who was therefore enabled to exercise his judgment as to the amounts of raw and of finished materials to be carried. By a proper selection of these and with an intimate knowledge of the speed of travel of each class of motors under his supervision, he was enabled to reduce the hitherto wide fluctuations in stocks and to have more nearly the right amount of parts constantly on hand, being at the same time not nearly so dependent as under the original plan, on other sections which supplied him with materials. Shipments were thus not only greatly facilitated, but both work in progress and stocks were decreased in marked degrees.

The very excellent showing made in the department selected for trial, led to the extension of the plan throughout the works until now they may be said to be quite fully departmentalized, at least as far as the manufacturing is concerned, and the general results have been but a confirmation of those obtained in the department first selected for trial. It will, of course, be appreciated that it is not practical to carry out a scheme of this kind in all departments, as in the cabinet shop, pattern shop and foundries; or in other places where either the work or the equipment is very special, as the insulating section, the blacksmith and the punch shops.

As at present arranged there are in the works eight fairly self-contained departments: the railway, for railway, mining and crane motors; the power, for large generators and motors; the control, for railway and industrial control apparatus; the detail, for switchboards and accessories, including line material; the small motor, for small power motors; the transformer; the locomotive; and the industrial, for medium sized motors.

From the accounting standpoint, departmentalization has been carried even further than it has on the manufacturing side, since practically every part of the works, regardless of whether it is a feeder section or a departmentalized unit, has been thus treated, giving a total of 53 such divisions. All accounts are balanced monthly. Each division has its own percentage of overhead burden; and as it is not the aim to show either a profit or a loss the percentages are altered as occasion makes necessary.

A set of charts is provided each division every month, showing a continuous record of its past performance along various lines, as total productive labor, total expense labor, total expense materials, these items in turn being subdivided in helpful ways.

Departmentalization on the basis of product or output has also been extended to the engineering, and, in rather lesser degree, to the sales department. In some instances the engineers and the sales correspondents are located alongside of one another, in order to facilitate as much as possible the routine work in connection with orders.

It will be recognized from the very brief description here given of the present plan of working at the East Pittsburgh plant of the Westinghouse Electric & Manufacturing Company, how difficult it would be to set forth rules for the guidance of others passing through a similar condition and, therefore, no attempt has been made to do so. It is furthermore not asserted that the plan outlined is the only correct way of operating a large and growing manufacturing concern; but, from the experience of the management and as borne out by certain recently published statistics, it is quite evident that it is the best course that can be prescribed for present requirements.

C. E. Clewell[1] said that there were three methods by which artificial light might be furnished: (*a*) the units used as individual lamps close to the work, one lamp being provided for each machine; (*b*) all the lamps mounted above the heads of the workmen, thus providing distributed light units over the entire floor space; (*c*) a combination of the two foregoing methods, that is, a small amount of general lighting supplemented by individual lamps over the various machines.

It is best, where possible, to do away with drop lamps and to install enough lamps mounted high and out of the ordinary field of vision to light the place properly. With the overhead system of lighting the entire floor space is lighted and the workman is not confined to a small spot of light cast by a drop lamp. All glare and dazzling effect may be avoided, as well as that fatigue of vision produced, in the absence of overhead light, by a constant traveling of the eye from the intensely lighted spot under the drop lamp to the considerably darker surroundings. The overhead system is also more economical, more pleasing and neater in appearance than where drop cords are used. There may be, however, some cases

[1] Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

where drop lamps are essential. This is notably the case with die-making, milling machines, and so on.

The adaptability of a certain quality and quantity of light to certain conditions is a test of time. Eye-strain and even permanent injury may result from the use of a given kind of light which, through ignorance, may seem fairly satisfactory to the user. In practice scarcely two locations will be found exactly alike. This makes necessary a careful study of nearly every case by the designing engineer.

Attention must be given to such points as the intensity of the light, its uniformity, and the reflectors to be used. These last are now designed in a scientific manner for distributing the light evenly over the floor space, a very desirable feature in manufacturing locations well filled with workmen, since a constant shifting of the work calls for light of equal quantity at any point where work is apt to be performed. Other items are the elimination of drop lamps in all but exceptional cases; the avoidance of the bright light shining from the lamp into the eye, or the glare, which is both harmful and annoying as well as inefficient in that it reduces the effectiveness of vision by a partially blinding tendency; the use of lamps of sizes which are consistent with the ceiling height, that is, where the ceiling is low, small lamps should be used and vice versa; in connection with incandescent lamps, reflectors which are scientifically designed must necessarily have the lamp filament at a particular point in the reflector in order to realize the highest efficiency, and for this reason the proper reflector holder should always be used.

The side light in overhead systems is often as important as the light thrown vertically downward by the lamp and reflector. The idea that the excellence of light is in proportion to the quantity is a mistake. Too much light may often be even more harmful to the eye than too little. None the less troublesome is the effect of lamps spaced too far apart, producing eye-strain and rendering the performance of good work impossible.

The wiring should be so arranged that the lamps may be controlled economically by fairly numerous switches, and that not too large an area of floor space is lighted by the lamps of each circuit; this allows certain lamps to be turned off when not required.

A maintenance department is an excellent way of taking systematic care of all the items associated with the upkeep of the lighting system. The lamps should be renewed as soon as burned out, or trimmed when necessary, and the reflectors and globes cleaned at sufficiently short intervals to insure an average condition of high efficiency. Large losses of light, as great as 40 to 50 per cent in the worst cases, are recorded due to accumulations of grease and dirt on glass reflectors and, as it would cost comparatively little to have them clean, there is no cause for the neglect of this item.

From the manager's point of view, good lighting is important because it helps towards greater accuracy of the work, the saving of the eyes, brighter and more pleasing surroundings, reduction of accidents, and the like. These items while difficult to estimate in money values really form the most important features connected with the problem.

As illustrating the small differences between good and inferior lighting the following hypothetical case is set forth, the conditions being, however, very nearly those of actual cases in existing machine shops. Making certain assumptions in the case of tungsten lighting as to energy cost, life of lamp, cleaning, interest, depreciation, etc., the annual operation and maintenance cost for a typical factory bay 16 ft. by 40 ft. may be taken as $50. Such a bay will accommodate say five workmen. If the wages of these men equal, say 25 cents per hour, the gross wages of the five men per annum may equal $3500. Adding to this the cost of superintendence and indirect expense, the gross cost of such a bay may equal $5000 to $7000. In such a case the lighting will cost $\frac{7}{10}$ to 1 per cent of the wages, or the equivalent of less than 4 to 6 minutes per day. Poor lighting will presumably cost at least one-half of this amount or the equivalent of 2 to 3 minutes per day. If therefore good light enables a man to do better and more work to the extent of 2 to 3 minutes per day, the installation of good lighting instead of poor will pay for the difference in cost. The usefulness therefore rather than the expense should be the leading thought and more progress may be looked for in the future if the shop manager will gain this attitude toward illumination as an aid to factory production rather than center all thought, as in the past, on the first outlay or the yearly expense.

G. H. STICKNEY [1] discussed the various methods of illumination. A few years ago there were two distinctly different methods, general illumination by arc lamps, and localized illumination by carbon filament incandescent lamps. The tungsten filament incandescent lamp, providing as it does a range of efficient units throughout the gap in capacities between the arc and carbon filament incandescent lamps, has led

[1] Electrical Engr., Genl. Elec. Co., Harrison, N. J.

to the creation of four classes of shop lighting, namely, (*a*) localized illumination with small lighting units; (*b*) general illumination with large lighting units; (*c*) combined localized and general illumination with both small and large units; and (*d*) localized-general illumination with units of intermediate capacity.

In localized illumination the lamp, usually a carbon filament incandescent lamp or other small unit, is hung over the machine or bench, and is usually under the control of the workman. The area illuminated is relatively small, and the intensity falls off rapidly from the point of maximum illumination. It is particularly adapted to certain conditions of manufacture. For example, illumination of deep borings, molds, interiors of cupolas, or other places where a general illumination could not well penetrate; illumination of straightening or inspecting processes, where the image or reflection of the light is specially employed, and in very fine work requiring an intense illumination over a small area. When not used to the best advantage, however, the localized lamp is apt to produce eye-strains, and when used without reflectors is not only wasteful of light, but makes it almost impossible to avoid glare.

Such lamps are often exposed to considerable breakage, and although low-priced lamps are used, the renewal cost is high. This, combined with the wear and tear on the extension cords, sometimes results in excessive maintenance expense, especially as the small unit makes necessary a large number of outlets.

With general illumination, an attempt is made to provide an approximately even intensity of illumination throughout a work-room. This ideal is never quite realized, except possibly when the lamps are hung at a considerable height. Lamps are usually spaced equally throughout a room, the most efficient illuminants are available, and since there are fewer outlets required, the initial wiring cost and maintenance expenses are likely to be relatively low. General illumination is best adapted to large high shops, especially where crane ways require the location of the lighting units along the sides of the room or above the cranes. General illumination is especially desirable, on account of safety, where large powerful moving machinery is used, as in rolling mills, erecting bays, iron foundries, and similar places.

Combined general and localized illumination is used in shops where a low or moderate intensity will answer most requirements, but where a higher illumination is required either at a few localized points, or only occasionally. For example, a group of automatic screw machines requires but a moderate general illumination when in operation, but when the workman has occasion to set up or adjust one of these machines, a more intense illumination is required at that particular point. Since a workman ordinarily attends to a number of these machines, it is good practice to provide him with a lamp and short extension which can be connected or plugged in at convenient points near the machines.

Mr. Stickney applied the term localized-general illumination to the practice of producing general illumination by means of units arranged regularly, but with reference to the machinery or processes to be lighted, so as to provide a higher intensity of illumination at important points than elsewhere. The units are located also with regard to giving suitable direction to the strongest light on a certain machine, thus avoiding objectionable shadows and reflections. The size of the units is selected to suit the spacing and amount of light necessary.

This practice has been brought about by the tungsten lamp which made available a series of efficient units throughout a large range of capacities. This type of illumination is now being used to a very large extent for looms, lathes and other machinery where the size and spacing of the machines is such as to permit fairly uniform spacing of lamps. It may be said to bridge the gap between localized and general illumination, and is made particularly effective by the ability to select units of any desired capacity and equip them with reflectors which concentrate or spread the light over wide or narrow angles.

H. O. STEWART[1] wrote a discussion of the question of how to determine the sum of money that might justifiably be expended on illumination. A daily departmental record of the output, the number of employees and of machines operated, should be kept, as well as a daily record of the local weather conditions and the time each day that the lights are turned on. With these data, the average hourly output per employee of each of the several departments, both during bright days when no artificial light is required and during cloudy days when it is, can be determined.

Assuming that it would be possible to increase the output during dark weather nearly up to that under the best conditions by means of first-class illumination, the maximum yearly amount to be spent for illumination can be roughly determined. In general it will be found that an investment of at least a part of that amount will be an exceedingly profitable one.

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[1] Rochester Ry. & Light Co., Rochester, N. Y.

Ideal factory illumination consists of sufficient light for each workman to perform his duties accurately and with maximum speed, and minimum glare both from direct light sources and polished surfaces, and freedom from objectionable shadows. The last can be reduced in magnitude either by increasing the number of light sources, or by better diffusion of light which may be accomplished by painting the ceiling with white oil paint and the walls with oil-paint of light color, and using prismatic or similar glass reflectors.

For foundry lighting, on account of the smoke and vapor in the air, a source of light with predominant red rays should be used, such as a flaming arc. The best type of lighting for a drafting room is the indirect system, with lamps contained in trough or bowl reflectors suspended a short distance below the ceiling. The light first strikes the ceiling and walls and is then reflected upon the drawing boards. The best results are obtained from flat ceilings and walls painted with white oil paint.

Luther D. Burlingame discussed the plan by which parts of a machine are manufactured as separate units, complete in themselves, the department where such units are built being to a large extent equipped with the different kinds of machines needed to perform the various operations required in their manufacture. This may be named the group department plan.

In taking up this discussion the questions may be raised, under what conditions is it of advantage to build parts of machines as distinct units, and how shall the machinery in the shop be grouped to manufacture them most economically.

Taking up the first question, some of the reasons for dividing a machine into separate units to aid in manufacture are: (*a*) where the nature of the unit is such that it can be manufactured to better advantage in a particular department equipped for that class of work; (*b*) where it is used for more than one machine and can be manufactured for stock in larger quantities than any of the machines on which it is used; (*c*) where there is a constant call for such part to be used either for repairs or on special machines; and (*d*) where the work is of such a nature that a sufficient saving can be effected to warrant manufacturing in larger quantities than in the case of the machine itself.

The system of manufacturing parts of machines as independent units has been in use by the Brown & Sharpe Manufacturing Company for many years, having been the subject of patents owned by that company but which have now expired. This principle of manufacture is applied to almost all lines of machines made by them. In investigating the systems in use by some progressive shops abroad recently Mr. Burlingame found it to be the almost universal practice to use some system of unit stock parts.

As an illustration of the kind of grouping referred to the spiral head of a milling machine might be mentioned. This forms a self-contained unit which can be manufactured to advantage in a separate department under this plan, a unit for the manufacture of which the foreman can be held responsible as to cost, time of completion, accuracy, and finish. The cost of such a unit can be known more exactly by this method than in the case where it is not separated from the complete machine, for by building it as a separate unit it is possible to know more exactly just where there is a gain in manufacturing and where there is a falling behind.

By the system here advocated all stages of the work for a complete unit of manufacture can be under the eye of a responsible man who can put all his experience and enthusiasm into reducing the cost, raising the standard of workmanship, and seeing that the work is completed at the time needed. This method of manufacture also gives a great degree of flexibility allowing for readily transferring the work or any part of it from one department to another.

A shop manufacturing a great variety of tools or machines and organized on this system may not only have all the advantages of one confined to a single product, including thorough attention to details and concentration on perfecting a given line of manufacture, but in addition there are special advantages making it possible to do work better and more economically by having men trained as specialists for each particular line of work, and it is also possible to have expensive special machines and equipment, the cost of which can only be warranted in a large shop.

The question of how the machines shall be arranged is not necessarily dependent on the size of the shop. The large shop may be arranged so as to be like a number of small shops but under one management.

When an important order is to be rushed through this method of manufacture has advantages over a method where each operation is performed in a different department, for the whole job in the former case can be under the eye and control of one foreman. Also by knowing all the ins and outs of the manufacture, intelligent suggestions for improvement and improved methods of manufacture are more likely to be made.

This brings us to the second consideration, as to how far a department should be organized to do all the necessary work itself on a given unit of manufacture, and how far parts of the work should be routed through special departments equipped for a particular kind of work. Some of these lines of division are well settled and we can pass them by and come to those where there is a difference of opinion and practice. For instance, it is hardly necessary to discuss the question as to whether there should be one foundry, forge shop, hardening room, smith shop, etc., to serve the whole shop, and it is almost universal practice to have all work for the departments of general grinding, gear cutting, screw making and polishing sent to the one department rather than to scatter the machines for such work throughout the works.

The more specialized the operations are the greater the reason thus to have the machines of a given kind together in a department to serve the whole shop. An argument in favor of such an arrangement is that it will require fewer machines to take care of a given product because there will be times of rush and times of idleness which can better be equalized if all the machines of a kind are together. This separating of machines of a given class into departments also makes it possible to put work in a size and kind of machine just suited to it, which is not always possible when these machines are scattered about the works. It might be contended that this same reasoning should extend to the locating of lathes, milling machines, drill presses, etc., as recommended under the output department plan. Experience has taught, however, that a combination of these different methods of dealing with shop work is often of advantage and that it becomes a question of deciding in each particular case where to draw the line to obtain the best results, everything considered.

In a line of manufacture such as the spiral heads, even though much of the work may be said to be carried on on the one-shop plan, many of the operations are performed in other departments than that in which the spiral heads as a whole are built and many of the parts are completely made in other departments. For example all the screws, studs, and some small parts are made in the screw machine department and carried in stock. The gears while being turned in the department where the spiral heads are made have their teeth cut in the gear cutting department. The index plates are drilled in a special department equipped for precision work of this character, the graduating also being done in this same department. The grinding is all done in the general grinding department. The various parts, however, are made and the operations performed on order from the foreman having charge of the manufacture of spiral heads, and he is held responsible for the completed work.

The decision as to which method to adopt depends wholly on an examination of each particular case and its requirements, and upon what combination of these methods can be used to produce the required results most economically.

H. M. Lambourn,[1] speaking upon the subject of shop floors, said that a selection of the materials best suited to a given structure could be made only after an investigation of the destructive agents to which all building materials are susceptible. No one material is best adapted to all cases.

The most active destructive agents commonly at work are attrition, due to use and vibration, fire, water, chemical reactions, and vegetable fungi.

In applying these elements of failure to factory floors, the supporting members of the structure are to be considered as an integral part of the flooring system, since the failure of the supporting members to fulfil their purpose of design would condemn an otherwise satisfactory structure.

The three systems of supports in common use in factory design are timber, steel and reinforced concrete, cost or fitness governing the application of each. Both timber and reinforced concrete have good resistance to destruction by fire in mill construction, and while the latter must take precedence, there is much to favor the former. Steel supporting work has failed so frequently in cases of fire that insurance engineering of the best character recommends its use in hazardous locations only when fireproofed.

Steel framework will transmit vibration much more readily than either timber or reinforced concrete, and is therefore not well suited for structures subject to shock from unbalanced machines or pure shock operations.

In the presence of moisture, reinforced concrete is the best material, with timber second, and unprotected steel the least desirable.

Active chemical fumes are best withstood by timber in the majority of structures, with reinforced concrete and steel about equally valuable. Acid-resisting coatings are not always effective, and the design in such cases should provide for easy replacement of structural members liable to attack.

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[1] Supt., Power and Plant, Yale & Towne Mfg. Co., Stamford, Conn.

Fungi and dry rot are to be considered only in the case of timber, and when there is a good circulation of fresh air little is to be feared from these causes.

In regard to the supporting floor proper, practically but two materials are in use, timber and reinforced concrete, upon which the additional floor coverings are laid if any are required. Two methods of design are in use in the timber supporting floors, in one of which planks of a width greater than the depth are either rabbeted on both edges and a suitable spline inserted, or also tongued and grooved; and a second in which square-edged planks of a depth equal to or greater than the width are spiked together. Of these two, the latter has several advantages, because of its stiffness against both deflection and vibration, due to the mass being intimately tied together, and also to the fact that the floor level and consequently the machine levels are unaffected by the warping of the plank, as in wide faced and heart timber. Moreover, it is little if any more expensive to lay than a close-fitting splined or tongued and grooved flooring. Reinforced concrete as a base or foundation flooring material has many advantages, the most important being its fire-resisting qualities. In the case of factories using much machinery, its freedom from vibration under usual conditions adds largely to the life of machinery and reduces the cost of replacements and repairs.

The difference in weight of concrete and wood, about 140 lb. against a probable average of 50 lb. per cu. ft., adds about three times the mass for equal thickness of floors, and consequently an increased inertia for equal vibrations. Reinforced concrete supporting floors for equal spans and strength are thicker than wooden floors, and consequently the mass is still more increased.

The question of freedom from vibration, other things being equal, in manufactories where duplication of parts is required, becomes a highly important factor in the cost of production. But quite equal in importance with stiffness against vibration is stiffness against deflection for the support of machinery whose proper functioning requires it to be level or within a given plane.

The elements of designing against deflection to prevent cracking of plaster are well understood, but in factory flooring deflection is seldom considered, or the assumed live load is supposed to cover the case, but with modern speeds, increased machine weights and duplicate manufacture, deflection in each case is worthy of fuller investigation.

Where a top or wearing floor covering is used, it is usual to add an intermediate flooring of thickness varying with the material of the supporting floor. In the case of a timber base, the intermediate floor is usually of boards, at right angles to the direction of the supporting plank, and so adds to the stiffness. With a reinforced-concrete base and a wooden wearing floor, the intermediate flooring of boards or plank is laid on screeds which have been bedded in tar concrete, or in cinder concrete, the purpose of this intermediate flooring being to make a ready fastening for machinery or a base for close nailing of the top flooring. Where waterproofing is applied, it should be placed under the intermediate flooring. All screeds should be chemically treated or else coated and laid in a bituminous envelope to preserve them against dry rot.

In factory floors the wearing surfaces are of wood, concrete, iron, brick, asphalt or clay.

The woods usually employed are Southern pine, either common sawn, rift or comb-dressed, maple, beech, birch, oak, hemlock, and spruce. Of these materials the most common are Southern pine and maple. Maple of a factory grade is being extensively used and has gained favor due to its wearing much more evenly and smoothly, its good resistance to wear and its favorable price. Beech and birch are not used generally, but frequently come mixed in small quantities with maple. The oldest flooring surface in modern factories is Southern pine, common cut. This material has usually worn well when the trees from which it was sawn have not been tapped to death and there was the required density to season well. The common cut has the disadvantage of breaking up in splinters when worn and so being dangerous. The rift cut or comb-dressed Southern pine overcomes the objection of splintering and has great wearing qualities. Its cost is somewhat greater than maple of the factory grade. Oak has been used and at the present time a factory grade is being produced which probably has greater resistance to wear though costing more than other wooden floor coverings. Hemlock and spruce are used only in the cheaper grades and are at best but poor substitutes for the harder and closer grained woods.

The face of the finishing flooring should not exceed 3 to 4 in., and should be planed with a hollow back and square edge, with or without a tongue and groove on the ends.

The square edge facilitates repairs, gives greatest floor covering surface for the board feet of flooring purchased, and is less expensive to lay. Face nailing should be used except in special cases, since blind nailing interferes with ready repairs.

Since the wear of floor surfaces comes mostly from travel and trucking, the floor boards should be laid in the direction of maximum travel, since a cross travel wears the boards much more quickly and unevenly. Uneven wearing is very detrimental to low production costs, where the finished product is of a perishable nature and cannot be subjected to rough handling. On the other hand, wooden wearing surfaces are perhaps the best from the standpoint of health, causing the least abstraction of bodily heat.

All wooden top flooring should be laid up with floor jacks, since there is not only a decided gain in the quality of the laid surface, but the same can be put down more quickly, and with less likelihood of nails splitting the boards. The nails should be cut; best of all, tempered steel cut nails, all well set after driving.

In the presence of much heat, large quantities of moisture and chemicals in bulk, wooden floor coverings should not be used.

There seem to be many valid objections to concrete floor coverings in the majority of cases. When first laid and well troweled, concrete makes a very attractive flooring, but as soon as use and wear begin becomes difficult of upkeep and repair. The wearing away of the first troweled surface is the beginning of much more rapid wear, and with a crack or joint once started there is soon developed a bad hole under shop trucking and handling of heavy materials.

Unquestionably, there is a much more rapid abstraction of bodily heat through the feet on a concrete floor surface with its attendant feeling of bodily discomfort. Where the character of the work produced is of a small or intricate nature and nervous rather than phlegmatic dispositions are required for rapid and economical manufacture, these conscious feelings of discomfort greatly decrease production.

In the presence of intense heat and free acids, a concrete surface is soon destroyed and because of the difficulty of repair becomes a burden of expense. By intense heat is meant such a condition as would arise where hot metal is spilled. The disintegration is here due to the probable presence of moisture and the kicking off of small particles from the sudden formation of steam. In places where there is not much wear, as in certain classes of store rooms, and where there is a liability of much moisture, as in wash rooms, concrete floor coverings are most acceptable. As a foundation material concrete in its several forms will probably be the most universally used material of building construction, but as a finishing material there is much yet to be developed in its methods of handling and treatment to place it in the front rank.

Cast-iron plates are excellent coverings for the runways of foundry floors and in places where hot metals are liable to be spilled, but in their use, care should be taken to place them where the character of wear will not cause them to become smooth.

Brick affords a good covering for floors where there is heavy trucking, much moisture, intense heat, or scouring wear, and in the foundry is finding more and more favor, one of its great advantages being its easy and unit replacement.

Asphalt coverings are susceptible of wide application in factory flooring, principally because of their water and acid resisting qualities, and partly because of their flexibility of installation when applied by trained workmen. They are also good fire retardants and are largely used where the nature of the material is inflammable.

The asphalt floors are found in plating rooms, toilet rooms, acid dip rooms, die houses, bleacheries, laquer rooms and similar locations. When applied over wooden floors they are first underlayed with a covering of building paper and the hot mastic properly tempered, poured on top. There have been some criticisms against asphalt coatings wrinkling after being laid, but this difficulty can be overcome by properly tempering the mixture of mastic and sand.

There have been brought out several composition floor coverings, and undoubtedly the most extensive comparative study of actual wearing qualities is now being conducted by the New York Central Railroad, at its Grand Central Depot. The records of these tests would make a most important addition to our knowledge of this class of floor coverings. There has been a recent replacement, in part, of one of these composition coverings at the New York Hippodrome, where slate treads were inserted in the place of composition treads on the stairs.

F. A. **Waldron** (written). The selection of design of a factory floor depends on the character of the product. Concrete, brick, wood, clay, asphalt, granolithic, mosaic, tile, terrazo, and patented compositions are all used successfully and economically. In factory development and construction as applied to light manufacturing, the concrete floor of equal parts of cement and sand is undoubtedly cheaper in first cost; its wearing qualities and means of repairing are, however, questionable. In a number of cases the dust from concrete floors has been found objectionable and it has been necessary to use a paint to prevent it. Also where operators are required to stand in one position all day it is not satisfactory and wood platforms are necessary.

In the writer's judgment wood top floor of beech, birch or maple, laid on tar concrete having nailing strips bedded about 16 in. apart, coating the wood with a good composition floor dressing, makes the best machine shop floor for buildings of this character. The first cost is about double the concrete and about the same as patented composition. It is more comfortable, can be repaired, is free from dust, and will allow more flexibility and more rapidity in relocation of machinery.

A much better piece of flooring is obtained by laying $1\frac{1}{4}$ in. N. C. sheathing diagonally on top of the tar concrete and then on top of this sheathing a $\frac{7}{8}$ in. beech, birch or maple flooring with two thicknesses of resin-sized paper between this top floor and the sheathing. This adds about 6 cents per sq. ft. to the cost.

These floors should never be laid on cinder concrete for shop use, as there is not the support between nailing strips and as the cinder concrete is laid below the line a dead air space is formed and the element of stiffness is also lacking. More complete combustion takes place in case of fire. Inflammable dust also sifts through cracks and accumulates in these spaces.

The surprising feature of the construction of the buildings described in the paper is the use of floor beams, when a flat slab would be much better in many ways, especially for light, belting, countershafts, electric wiring and sprinklers, water and steam piping.

In the choice of materials for top flooring, the following order should be observed: maple, beech, birch, edge grain yellow pine, although the last named wood will not last as long on floors where there is trucking as it will on stairways. Experiments have shown that edge grain yellow pine stair treads will outlast two maple, birch or beech treads.

Henry K. Rowell (written). The chief reason for using reinforced-concrete construction in place of the slow-burning mill construction for textile mills seems to be the growing scarcity of timber. The expense of reinforced construction is about 25 per cent more. For a modern slow-burning type of mill for the textile industry the insurance rates will be assessed from one-half to three-quarters of one per cent on the insurable value, and the premium rates will be further reduced by dividends. So small have been the losses of buildings from fire in the textile industry in this type of construction that it is almost a negligible amount. As an offset to any saving in the insurance due to reinforced concrete, there would be the increased assessment of taxes, as it seems reasonable to assume that a higher assessment would be made on the more valuable building. The writer does not know of any case where such a comparison could actually be made. It remains a question of fact as to which would be considered of the higher market value, the slow-burning or reinforced-concrete types of construction.

In the matter of the depreciation of a plant, the rate would probably be about equal as between the two types. The physical life of the reinforced-concrete buildings would be assumed as greater probably, but, except in the case of dye houses, this is open to question, as worn bearings due to cement dust, extra repairs required for looms owing to a too rigid floor, and the cracking of walls, floors and beams, etc., would appear to indicate. Buildings depreciate not only because of wear but also of adaptability to use, due to advancement in the mechanical arts.

With reference to the hardness of concrete floors, while people soon become accustomed to their environment and cease to complain, any one, and particularly a woman or child, subject to the unyielding quality of stone, brick or concrete, must fatigue more rapidly than those subject to the more elastic quality of wood.

The difficulty in patching worn places in the floors seems to be one of the serious difficulties with a granolithic floor. The matter of drilling holes through the floor for holding down bolts seems objectionable, also. Where holes are drilled through the ceiling of a card room, when the floor above is washed every hole affords a channel for water to run down and drop on to the cards and subject the mill to a loss of perhaps hundreds of dollars worth of card clothing.

The board overlay would seem to be more satisfactory since it offers an easier medium to stand upon and because machinery can be screwed to the floor easily without destroying the concrete. The floors can be made waterproof and the boards easily replaced when they become worn.

In the experience of the writer, a reinforced-concrete floor with granolithic finished surface was built in an engine room. The engine was installed and after running a short time it was noticed that the bearings were becoming cut with grit and wearing badly. The floor was then entirely covered with linoleum glued down hard, and there was no more appreciable wearing in the bearings. The linoleum was easily kept clean and proved very satisfactory.

In the matter of insurance for a textile mill, the writer had occasion to take this matter up with an insurance company who assured him that the rates were practically the same for both reinforced-concrete and slow-burning types. The chief advantage of the reinforced-concrete building is that a fire can be more easily confined to one room, but owing to the light inflammable material in the machines a fire once started will sweep through the room very rapidly and will flash over the floor if it is oily. The risk is not much greater, therefore, in either case. Fortunately the machinery builders are using steel now where they once used wood.

FOREIGN REVIEW

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

An Index to Current Articles in Foreign
Periodicals, with Abstracts of Some
of the More Important

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TOPICAL INDEX OF CURRENT ARTICLES[1]

Aeronautics

(See also Internal Combustion Engines, and Strength of Materials).

Zugkraftdiagramme von Flugzeugen, Georg König. *Zeits. für Flugtechnik und Motorluftschiffahrt*, December 30, 1911. 4 pp., 9 figs. *h.* Theoretical investigation of principles underlying the determination of *necessary and available tractive power for airships.*

Luftwiderstandsversuche mit gröszeren Aeroplanflächen, A. von-Parseval. *Zeits. des Vereines deutscher Ingenieure*, December 30, 1911. 3 pp., 21 figs. *d.* Describes tests on *resistance of air* with respect to large aeroplane surfaces made by the author and Colonel von Siegsfeld in 1890 and 1891.

Une question d'équilibre, C. F. *La Technique automobile et aérienne*, January 15, 1912. 2½ pp., 2 figs. *e.* The author, following a former investigation by Mr. Esnault-Pelterie, proves mathematically that a motor with a fan-like arrangement of cylinders cannot be as perfectly balanced as a motor with a star-like arrangement. He compares the two types, with special regard to their application in aeronautics. The fan-like motor admits of a perfect lubrication, which is very difficult to get at in a star-like motor, but cannot be as perfectly balanced, and is apt to produce undesirable vibrations in the machine. This did not matter much as long as aerial motors were small, but when Mr. Esnault-Pelterie started to manufacture a 90-h.p. motor he was perfectly justified in replacing his former fan-like arrangement by a star-like one.

Cranes

Flytekran drevet av Petroleumsmotor. *Teknisk Ukeblad*, January 19, 1912. 1 p., 1 fig. *b.* Describes a floating crane equipped with an oil motor built for the Dry Dock Company of Rotterdam, Holland.

Versuche über die Spannungsverteilung in Kranhaken, E. Preusz. *Zeits. des Vereines deutscher Ingenieure*, December 30, 1911. 4 pp., 18 figs. *e.* Description and data of tests on the distribution of strain in crane hooks.

Fuel

Die Selbstentzündung der Kohle, Schorrig. *Zeits. für Dampfkessel und Maschinenbetrieb*, January 5, 1912. 2½ pp. *h.* Exposition of several theories, mainly German, on the causes of spontaneous combustion of coal and lignite briquettes.

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[1] Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *a* comparative; *b* descriptive; *c* experimental; *d* historical; *e* mathematical; *f* practical; *g* general; *h* theoretical. Articles of exceptional merit are rated *A* by the reviewer.

Ausnutzung minderwertiger Brennstoffe auf Zechen des Oberbergamtsbezirks Dortmund. Bütow and Dobbelstein. *Glückauf*, January 6, 1912. 14 pp., 28 curves. *c.* Data of an investigation to determine the economic possibilities of the use of *cheap grades of fuels.*

Die Verwertung von Naturgasen durch Verbrennung unter Dampf- und Destillierkesseln. Karl Feldmann. *Petroleum*, December 20, 1911. 3 pp., 8 figs. *f.* Discusses various methods of *utilizing natural gas*, and describes various systems of burners, among others those used in Galizia and Caucasus.

Økonomisk Opvarmning av vore Boliger, Kjeld Helgeby. *Teknisk Ukeblad*, January 5, 1912. 3½ pp. *a.* Compares various systems of heating from the economic standpoint. Under Norwegian conditions (in particular for Trondheim) electricity appears to be the most expensive fuel 2.70 öre per 1000 calories of useful heat, or $0.015 per 1000 B.t.u., at a price of 80 öre ($0.18) per kw-hr., while peat is the cheapest—0.96 öre per 1000 calories of useful heat, or $0.006 per 1000 B.t.u.

Sul comportamento dei carboni da gas nella distillazione in grande massa, D. Menenghini. *L'Industria*, January 17, 1912. 2½ pp., 1 fig. *f.* The author finds Campredon's method of measuring the caking capacity of bituminous coal[1] inadequate in the case of gas coal: *(a)* because sand 17 to 20 times the weight of coal would have to be added, and that would make it very difficult to obtain a uniform mixture of the coal and sand; *(b)* because the basic materials in the coal may produce a cementation of the silicate in addition to what is done by its bituminous constituents. Dr. Menenghini offers, therefore, the following method, which gives both the caking capacity of the coal, and its increase in volume at gasification. He found that there is for each type of bituminous coal a nearly constant relation between the amount of volatile substances contained in the coal and the amount of clean fine sand which the coal can take in (cake in) at gasification. The method consists in placing a gram of finely powdered coal in a platinum crucible, and pouring over it in a fine stream, so as to completely cover the coal, two grams of fine clean silicon sand; the amount of coke is determined by the American method.

Hydraulics

Vattenturbinerna för Statens kraftverk vid Trollhättan, K. Dahlgren. *Teknisk Tidsskrift-Mekanik*, January, 1912. 7 pp., 17 figs. *b.* Describes the water turbines at the Trollhättan hydroelectric plant.

Beitrag zur Nachrechnung und Auslegung von Bremsversuchen an Wasserturbinen nach dem Diagramm von Prof. Dr. Camerer, Otto Böhm. *Zeits. für das gesamte Turbinenwesen*, January 10, 1912. 4 pp., 12 figs. *h.* The first of a series of articles on the calculation, using Professor Camerer's diagrams, of the *actual power delivered by the water, and the losses in, the turbine*, from the mean values indicated by the brake test.

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[1] Guide du chimiste métallurgiste et de l'essayeur, Campredon. A certain amount of coal is caked in a vessel, and fine sand added, as long as the coal is able to take it in and form a solid block. The amount of sand taken in shows the caking capacity of the coal.

Internal Combustion Engines

Vergaser auf der Automobilausstellung 1911, A. Berger. *Der Motorwagen*, December 31, 1911. 4 pp., 7 figs. *b.* Describes various systems of *carburetors:* Zenith, Marvel, Solex, Sperber, Brennabor, Favorite, and Fiat.

Moderne Gaserzeuger im Glashüttenbetrieb, K. Quasebart. *Sprechsaal*, January 4, 1912. 1½ pp., 3 figs. *b.* Description of *gas producers used in the glass industry.* Only high-grade fuels can be used for smelting glass.

Nye kraftmaskiner i 1911, C. F. Helmboe. *Elektroteknisk Tidsskrift*, January, 1912. 2 pp., 3 figs. *b.* Description of the Holzwarth gas turbine and Tesla steam turbine. The part referring to the Holzwarth gas turbine is a translation from Mr. Holzwarth's book on that subject, and can be found in English in Power, February 6, 1912.

Seefischerei-Motoren, F. Romberg. *Dinglers Polytechnisches Journal*, January 6, 1912. 6 pp., 40 figs. *bf.* Analysis of conditions which a *motor for fishing crafts* must satisfy, and description of some of the German types.

Neuere Rohölmotoren, Ch. Pöhlmann. *Dinglers Polytechnishes Journal*, January 27, 1912. 2½ pp., 2 sheets of drawings. *b.* There seem to be advantages in providing large *Diesel engines with crossheads.* If the cylinders have to take care of the pressure on the guide face they must be correspondingly large and strong, and therefore expensive; the wear and tear of the liners and cylinders is also quite appreciable, and, since as a rule the piston is not adjustable, there develops a jerky, noisy working and poor volumetric efficiency. A further disadvantage of engines without crossheads consists in the fact that the piston-pin is inside the hot piston, and that makes the cooling more difficult. The lubricating materials become, owing to the high temperature, very fluid, and give poorer lubrication. Therefore high pressures on piston pins cannot be used, and 120 kg/qcm (about 1600 lb. per sq. in.) is probably the maximum allowable, while for crosshead pins which move in open air, pressures as high as 150 kg/qcm (say 2000 lb. per sq. in.) and even higher may be safely used.

The only firm in Europe which builds crosshead Diesel engines is the Grazer Waggon- und Maschinenfabrik-A.-G. Their engine is of the four-cylinder four-cycle type, 600 mm. (23.6 in.) bore, and 800 mm. (31.4 in.) stroke, with the cylinders in two twin groups, and gives 800 effective h.p. at 160 r. p. m. The bed-plate, 7.73 m. (25.3 ft.) long, is cast in two pieces and bolted together in the middle. The crank-bearing is long and as a result the maximum specific pressure at the bearings is very small, and at starting amounts per sq. cm. of the pin surface to only 30.5 kg. (433 lb. per sq. in.), and when running 26 kg. (370 lb. per sq. in.).

The hollow crankshaft is in two parts, with flanges, joined at the middle, and is cooled by water entering axially at the left end.

The forked connecting rod is made hollow and carries at its upper end the crosshead beam of the one slipper crosshead. Since the latter moves in free air the pressures on it are allowed to be as high as 130 kg/qcm (1740 lb. per sq. in.) when running and 150 kg/qcm (2000 lb. per sq. in.)

at starting. The crosshead guide face, which has to withstand a pressure of more than 11 tons during expansion, has a cylindrical guide. The slipper of the crosshead which takes up the comparatively small pressure of the compression stroke is provided with adjustable flat guide plates. The piston lubrication is rather peculiar. The cylinder bush has a number of holes bored through it parallel to the axis and ending at a certain height in a common ring-shaped oil groove. The oil enters these holes under pressure and, on coming out from the cylinder bush, is collected in a ring-shaped trough at the lower end of the cylinder liner. The piston has at its lower end a cylindrical iron wiper which dips into the oil trough when the piston reaches the lower dead centre, and carries it up with a few drops of oil, thus preventing waste and danger.

DIE DAMPFZERSETZUNGSFÄHIGKEIT DER GASERZEUGER, Hudler. *Glückauf*, December 30, 1911. 3 pp. *h*. An attempt to answer the question, *How much steam per unit of weight of combustible must be brought to the producer grate in order to convert the largest amount of available heat into chemical energy.* The author operates with the data obtained by Bone, Wheeler and Alleut from experiments with a Mond producer of 3 m. (9.84 ft.) in diameter, and a power-gas producer ¼ m. (say 10 in.) in diameter. The efficiency of the Mond producer per heat unit was always higher than that of the small producer, but in the Mond producer the content of CO_2 rapidly increased with the increase of content of hydrogen, while in the small producer it changed very little. The author calculates heat balances for both producers, and comes to the conclusion that CO_2 in the small producer is made up of oxygen from the air, and in the Mond producer from the decomposition of steam, and that this is the reason why the content of hydrogen increases simultaneously with it. He shows further that the efficiency of a Dowson gas producer, expressed in chemical energy, is directly proportional to its dimensions, provided the load per unit of cross-section is the same.

L'INFLUENCE DE L'ALTITUDE SUR LA CARBURATION, A. Lauret. *La Technique automobile et aérienne.* January 15, 1912. 2 pp. *h*. The author attempts to explain why *carburetors* give trouble in automobiles at some 3000 to 4500 ft. *above sea level*, and gave no trouble to Garros when he went up about 14,000 ft. with a Zenith carburetor. As the elevation increases the density of air decreases, the amount of air drawn into the carburetor decreases also, and that results in a proportional decrease of the amount of explosive mixture. On the other hand the absolute compression pressure decreases also, but then the back-pressure of exhaust is smaller, and the last gives to the motor an important advantage. That the mixture becomes richer as the compression decreases is comparatively slightly known.

As regards the influence of high elevation on the speed of rotation of a motor, the author shows that as the density of air decreases the head resistance decreases also, but so does the raising force of the air, the last making it necessary either to increase the angle of incidence of the wings, or to increase the speed of translation which is made difficult by the decrease of resistance which the air offers to the propeller. All this makes the problem of conditions of flight at high altitudes somewhat complicated.

The author proceeds to show mathematically that the action of a carburetor of the Krebs type (compressed air type) depends entirely on the density of the air drawn in, and when that changes it is not enough to reduce the jet spray nozzle, but the tension of the spring of the supplementary air valve must be changed. At high altitudes the carburetor does not remain automatic, but delivers more fuel than is necessary, which is especially inconvenient, as there is already a tendency toward the mixture becoming too rich. In a carburetor on the regulation of supply of fuel principle, such as the Zenith, the action depends on the amount of fuel delivered, and is independent of the density of the air, thus making possible an automatic regulation of carburation even at high altitudes.

Die Internationale Ausstellung von Verbrennungsmotoren in St. Petersburg 1910, N. Bikoff and G. von Doepp. *Die Gasmotorentechnik*, January, 1912. 7 pp., 10 figs. *b.* Describes engines at the International Exhibition of Internal Combustion Engines in St. Petersburg in 1910, including Swedish types of the Motala and Bolinder Companies in Stockholm. The Bolinder motor has a peculiar construction of the cylinder cover and explosion chamber, which is connected with the inside of the cylinder by two inclined ducts, through one of which the atomised fuel is led to the explosion chamber from the atomiser, the usual screw in the atomiser not being used in this motor. The timing of ignition is done by the water injected into the cylinder, the water coming through a little boiler from the cooling jacket to the cylinder, and the amount of it being regulated by hand according to the load.

Kraftgasgeneratorlage für Feinkohle, H. L. *Braunkohle*, January 12, 1912. 2½ pp., 1 fig. *b.* Description of the Petzold *step-grate gas producer* for slack coal. The inventor gets rid of the usual trouble with slack coal gas producers (high percentage of carbon dioxide in the gas) by building an inclined wall against the bottom of the step-grate. This wall does not permit the gases to pass directly to the gas holder, but forces them through the glowing fuel, thereby considerably reducing the contents of CO_2. For a complete reduction of the carbon dioxide it is necessary, however, that the fuel be packed close to the wall, and that there be no holes between it and the wall.

Note au sujet de l'Équilibrage des moteurs à combustion interne à allure rapide, Hutter. *Mémorial du Génie Maritime*, December, 1911. 32 pp., 15 figs. *h.* Investigation in the theory of balancing of high-speed internal-combustion motors. The author investigates the influence of angular accelerations, and shows that even slight irregularities, if they are sudden, may give rise to considerable inertia forces. A new condition for balancing the forces of inertia is, therefore, introduced: the cylinders must be adjusted in such a way as to insure the greatest possible regularity of the motor couple. Proper balancing of an engine affects its efficiency. Even slight vibrations if rapid, when transmitted to the engine body, represent a serious loss of power, and may even lead to a breakdown.

Les moteurs sans soupapes à quatre temps, G. Lavergne. *Revue générale des sciences*, January 15, 1912. 8 pp., 12 figs. *b.* Describes various *four-cycle motors without poppet valves.* Besides the Knight motor, the following are described and illustrated: The *Rolland-Pilain motor* (Fig. 2) has a cylindrical shell with liner placed between the piston and the cylinder and supporting a long segment *S* provided with admission and exhaust openings *A* and *E*. These openings are on the same level, while the admission and exhaust ports in the cylinder are on different levels. The liner is given such a motion that the segment *S* closes perfectly tight the admission and exhaust ports during the periods of compression and explosion. This could not be done by a connecting rod and eccentric, and the following arrangement is made use of: two eccentrics are used, one on the crankshaft, and the other on a half-speed shaft driven by an endless chain from the crankshaft. Two points on these eccentrics are joined by connecting rods with the ends of a beam, in its turn connected with the liner of the cylinder. Admission and exhaust can be advanced or retarded by changing the length of the pieces in this gear. There is considerable play between the liner and the cylinder, and only the segment has a tight fit. It seems therefore that seizing of the valve gear is less likely here than in the Knight motor. The *Mustad motor* (Fig. 1) has also a liner, but it is divided into two parts *A* and *A′*, of which the first takes care of the exhaust port *E*, and the other of the admission port *C*. They are actuated by connecting rods *B* and *B′* driven by eccentrics from two shafts rotating at half the speed of the crankshaft, and connected with it by a gear not shown in the drawing. The manufacturers claim that a four-cylinder motor, with a bore of 90 mm. (3.54 in.) and stroke 110 mm. (4.32 in.), delivers 28.5 h.p. at 1500 r.p.m., with a consumption of only 221 grams (0.486 lb.) of oil per h.p-hr., with a maximum output of 33 h.p. The *Miesse motor* (Fig. 3) has also a cylindrical liner *A* actuated by a mechanism *B* driven from a half-speed shaft, but the liner opens and closes a single orifice *D* which serves both for the

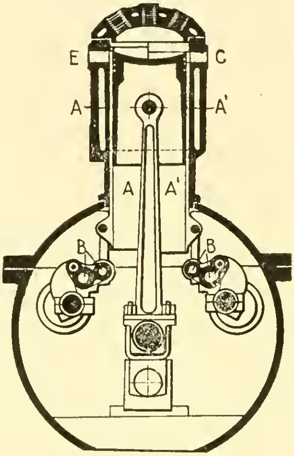

Fig. 1 Mustad Motor

admission and exhaust. To do that, a cylindrical slide valve *H* consisting of two interconnected pistons and actuated, like the liner, by the mechanism *B*, brings against the orifice first the admission, and then the exhaust port. This arrangement has the advantage of cooling, by the passage of fresh gases, the orifice heated by the exhaust. The *Berliet motor* has the cylindrical slide valve of the Miesse motor, but no liner. The author proceeds to describe the motors of Henriot, Cottereau, and Broc which have been already described in The Automobile (August 3, 1911), and the motors of Boissier and Ballot, which are modifications of the Henriot type.

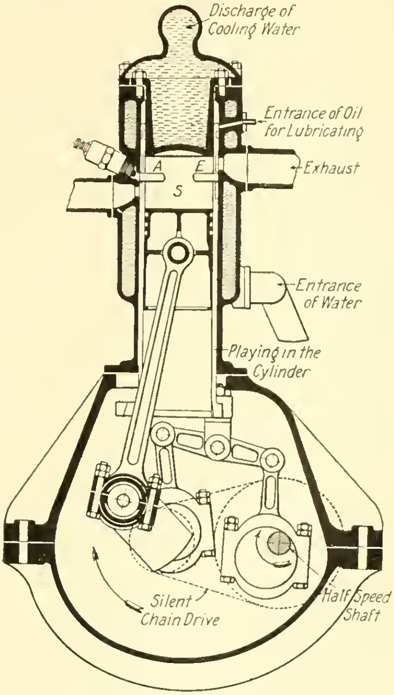

Fig. 2 Rolland-Pilain Motor

Beitrag zur Frage der Abwärmeausnutzung bei Gasmaschinen, C. Semmler. *Dinglers Polytechnisches Journal*, January 20, 1912. 3 pp., 7 figs. *b*. A modern double-acting large gas engine consumes about 2400 WE (about 9600 B.t.u.) per second per effective horsepower, this amount being utilised as follows: 26 per cent for effective work, 5 per cent in mechanical losses, 35 per cent in losses in water cooling, 34 per cent in losses due to exhaust, etc. The author describes an arrangement invented by himself for *utilising* the last two items, i. e., *heat now lost in water cooling and exhaust*, but first calls attention to the fact that in the present gas engines the cooling water is heated to about 60 deg. cent. (140 deg. fahr.) at atmospheric pressure, and that this leads to the formation of considerable amounts of steam at the contact with the hot cylinder walls, and consequent low efficiency of cooling, the latter being made still lower by the formation of scale due to the use of imperfectly clean water. The arrangement used by the author is shown in Fig. 4, where M is the engine cylinder, and K a boiler with a pressure of ½ atmosphere above atmospheric, and temperature about 110 deg. cent. (230 deg. fahr.), the water level in the boiler being about 10 m. (say 40 ft.) above the motor. The water pressure in the cylinder jacket is therefore equal to about two atmospheres, and the boiling point about 120 deg. cent. (248 deg. fahr.). If the water is sent from the boiler, by the pump P, through the cylinder jacket at such a rate that it has time to heat from 110 deg. to 115 deg. (239 deg. fahr.), there will be no formation of steam around the motor, but steam will freely form at W_2, where there is practically no water pressure. The formation of steam in the way desired can be made still more certain by making the pressure around the motor equal to, say, 5 atmospheres (corresponding to a boiling point of 151 deg. cent. or 303.8 deg. fahr.). This can be attained by reducing the cross-section at W_2. This arrangement permits the conducting of all the heat in the cooling water to the boiler K. The steam produced in the boiler is then led to the superheater U, and heated there by the exhaust gases of the motor having a temperature of 400 to 500 deg. cent. (752 to 932 deg. fahr.) and following the path $G_1G_2G_3$. The steam is superheated to about 300 or 350 deg. cent. (575 to 662 deg. fahr.), and conducted along the path DD_1D_2 to a low pressure steam turbine T which may drive a dynamo Dy. From the turbine the steam is led through D_4 to a surface condenser C, and the water of condensation returned to the boiler K by means of the feed-pump Sp, passing partly around the motor, and thus both cooling the motor and being pre-

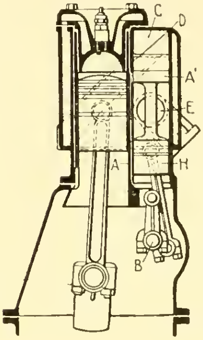

Fig. 3 Miesse Motor

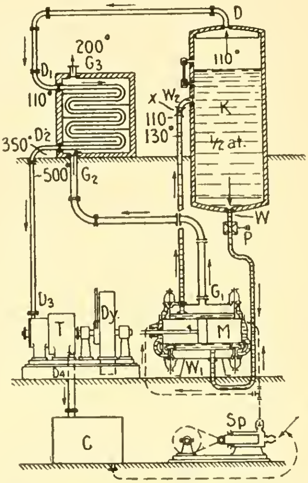

Fig. 4 Semmler's Arrangement for Utilizing Waste Heat of a Gas Engine

heated itself. Since only chemically pure water is used, and no formation of steam in the cylinder jacket is allowed, a very intensive cooling is obtained, and all trouble with scale is avoided.

The author proceeds to show that the same system may be used not only for individual motors, but for groups, and that about 3000 additional effective h.p. may be obtained by this method from an installation having 20,000 h.p.

DER DIRECT UMSTEUERBARE SCHIFFSDIESELMOTOR DER RHEINISCHEN GASMOTORENFABRIK, A.-G. BENZ & CIE., MANNHEIM, Ch. Pöhlmann. *Electrotechnische Zeits.*, January 25, 1912. 2 pp., 4 figs. *b*. Description of the *Diesel reversible marine engine*, designed by the Swedish engineer Hesselman, and now manufactured by Benz & Co. in Germany. It is a two-cycle engine without poppet valves, with two or four working cylinders, and two double-acting scavenging pump cylinders, the latter serving at starting for the purpose of manoeuvering. It is claimed that this construction has the following advantages: (*a*) the air pressure in the manoeuvering cylinders may be as low as desired, since it is absolutely independent of the degree of compression in the working cylinders; (*b*) immediately after the reversal of the direction of motion, the working cylinders may be set on ignition, while the manoeuvering part still works with compressed air: the engine then rapidly reaches the required speed of rotation, and the consumption of air is very low. The atomiser is built into the fuel valve. It is built on the principle that as the fuel is converted from a viscous liquid into a fluid foggy stream, the angle made by the edges of the atomiser and the area of its cross-section must both increase: a viscous liquid is best atomised by throwing it against sharp edges, while a fluid stream is more effectively broken into spray when striking broader surfaces. In accordance with this, the Hesselman atomiser is provided first with a sharp edge, then with two edges forming nearly right angles, and finally, near the needle, with an edge making an obtuse angle, in addition to which there is some extra space left in front of the nozzle plate. This construction (Fig. 5) produces, as the author claims to have seen personally, an

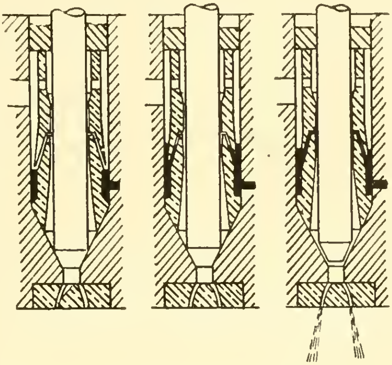

FIG. 5 HESSELMAN ATOMISER OF THE HESSELMAN-BENZ REVERSIBLE DIESEL ENGINE (BLACK LINES SHOW PATH OF FUEL)

uncommonly low consumption of combustible for an engine without poppet valves (no figures are given), and an absolutely smokeless combustion.

Machine Shop

Die Verzinkung nach dem Schoopschen Metallspritz-Verfahren, M. U. Schoop. *Acetylene*, No. 1, 1912. 6 pp., 16 figs. *b.* Nouveau procédé de métallisation du Dr. Schoop. *H. de F. Bulletin technique de l'Association des Ingénieurs sortis de l'École Polytechnique de Bruxelles*, December, 1911. 2 pp. *b.* Description of and some data on the *Schoop process of metallisation* (galvanising). The process is a further development of Sherardisation, and consists in projecting on the object intended to be metallised a liquid metal in such a fine spray and with such a velocity that the metal is reduced to a state of intangible fog. To do this the metal is melted in special crucibles, out of which it flows in a thin stream by its own gravity or under air pressure, and this stream is further broken into a spray and projected forward with great velocity by a jet of steam or other fluid. Although the metal is really in a molten state, the temperature of the "fog," probably owing to the cooling effect of the expansion of the gas in the carrying jet, is so low that it was found possible to metallise lace without injuring it. The layer of metal is said to adhere very well, and to be of great hardness and uniformity of structure. Professor Kaiser-Paris claims to be able to preserve eggs for an indefinitely long time by this process.

Neue Arbeitsweise beim Emaillieren, P. *Metall-Technik*, January 13, 1912. ½ p. *b.* The new process of Septimus and Albin Sonntag is claimed to be a simple and certain method of uniformly *enamelling metallic objects*, irrespective of shape or size. The surface of the object is uniformly moistened by placing the object in a vapor bath, or playing upon it with a stream of vapor (dipping the object in water does not produce uniform moistening, because metals are apt to repel unatomised water); enamel powder is then strewn over the object through a sieve, and sticks uniformly all over it; to put on a second layer of enamel powder the process is repeated. After the powder is laid on, the object is placed in the furnace as usual. It is claimed that the absence of fluxes or binders of any kind helps the enamel to preserve its color, brilliancy and transparency.

Tour à charioter et à fileter pour acier, à coupe rapide, H. Ernault. *Portefeuille économique des machines*, January, 1912. 1 p., 1 fig. and 1 plate of drawings. *b.* Describes an *engine lathe* with screw cutting attachment, with detailed drawings of same. The lathe is made with extreme precision.

Machine à retreindre les tiges et tubes métalliques système Bliss, M. Lunet, *Le Génie Civil*, January 27, 1912. 2 pp., 11 figs. *b.* Describes a machine manufactured by E. W. Bliss Co., of Paris, France, for *reducing the diameter of metal rods and pipes.* The rod or pipe is placed between two metal members rotating about a centre on the axis of the rod or pipe. While rotating, the two members by radially projecting pieces strike a series of cylindrical rollers disposed along the path of rotation, and then by recoiling rapidly and uniformly strike the piece which has to be reduced in diameter. When the piece is heavy, and strokes in very rapid succession might not prove convenient, the rollers against which the projecting pieces strike are disposed in a sort of cage, which is free to rotate with the striking members. When the roller is struck it, together with the striking member, moves a little, producing thereby a powerful pressure instead of a short, sharp stroke. The machine appears to be simple in construction, and is claimed to be efficient.

Das Fräsen von Zahnrädern, C. Brückner. *Zeits. des Vereines deutscher Ingenieure*, December 30, 1911. 3 pp., 2 figs. *f.* Discusses *gear cutting* with special attention to the question of cutting speed and rate of feed. Article includes tables.

Eine Flügelbohrmaschine von Ernst Schiesz in Düsseldorf, Nickel. *Zeits. des Vereines deutscher Ingenieure*, December 30, 1911. 1 p., 1 fig. *b.* Describes a *radial drilling machine* built by the above named concern.

Le zingage du fer et de l'acier, Sang. *Revue de métallurgie*, January, 1912. 34 pp. *b.* Discussion of various methods of *galvanising iron and steel*, and testing the quality of the material produced. The article is of a general nature, and is an introduction to a more detailed discussion of the three main methods of galvanisation by molten zinc, electrolysis and sherardisation, which will follow.

Mechanics

Note sur la théorie des engrenages, Garnier. *Revue de mécanique*, December, 1911. 22 pp., 21 figs. *b.* End of an investigation on the theory of *gearing*.

Über Schmiermittel, Franz Helbig. *Braunkohle*, January 12, 1912. 2 pp. *b.* A popular discussion of the problem of *lubrication*.

Le catene Renold pel comando di regolatori ed alberi di distribuzione. *L'Industria*, January 17, 1912. 2 pp., 6 figs. *b.* Describes some British applications of *Renold's silent chains* for driving governor and sideshafts.

Das hydrodynamische Getriebe von Föttinger, H. Hoff. *Stahl und Eisen*, January 11, 1912. 7 pp., 14 figs. *b.* Describes latest types of Föttinger's *hydrodynamic transmission*, mainly with regard to the possibility of its use in metallurgy. With a ratio of transmission of 1:5, a total efficiency of 0.87 was reached, and the efficiency rose to 0.97 for a ratio of transmission of 1:1.

Die Verteilung des senkrechten Radialdruckes auf die Kugeln eines Kugellagers, Th. Lehmbeck. *Zeits. des Mitteleuropäischen Motorwagen Vereins*, End December, 1911. 3 pp., 4 figs. *e.* Investigation of the distribution of vertical radial pressures among balls in *ball bearings* made by the author in the Laboratory of the German Arms and Munition Factories, with a table of data obtained. The distribution of pressures does not agree with theoretical calculations, and exceeds it sometimes by 25 per cent. The distribution of pressure is not so unfavorable, as was asserted, that two or three balls carry the whole vertical radial pressure. The author found that from four to five balls carry the pressure, and four of them carry considerable loads.

STATISCHE BERECHNUNG FLACH GEWÖLBTER GASBEHÄLTERKUPPELN FÜR EINSEITIGE SCHNEELAST, J. Schmidt. *Journal für Gasbeleuchtung*, December 30, 1911. 7 pp., 22 figs. *cf.* Method of determining the shape of a *flat arch roof* of a *gasholder* with regard to its ability to support a snow load. The method applies only to Schwedler flat arch roofs. A full solution of one example is given in the article.

RÉSISTANCE DES PIEUX, J. Benabenq. *Annales des Ponts et Chaussées*, September to December, 1911. 150 pp., 34 figs. *ccA.* Partly mathematical, partly experimental investigation of the forces acting on, and resistance of, *piles*, both statically and dynamically. The author shows that the statical method is both exact and general, and ought to be applied as a rule, both for the calculation of straight and of screw piles. Dynamic formulae are only approximately correct, and can be used only for the case when the pile goes down to bottom rock. The author proposes a new formula sufficiently correct for this case. (For a shorter abstract see Génie Civil, Jan. 27, 1912, article by Ch. Lantin.)

ÜBER DEN MECHANISMUS DES FLÜSSIGKEITS- UND LUFTWIDERSTANDES, Th. von Kármán und H. Rubach. *Physikalische Zeits*, January 15, 1912. 10 pp., 3 figs. *ch.* Mathematical investigation of the *resistance of liquids and air* when this resistance is proportional to the square of the velocity, which happens when the velocity is considerable. The values analytically obtained by the author agree fairly well with those obtained experimentally by Föppl and Eiffel.

Steam Engineering

SUR UN COMPTEUR DE VAPEUR, H. Parenty. *Comptes rendus des séances de l'Academie des Sciences*, January 2, 1912. 2 pp., 1 fig. *bd.* The author claims that all the *steam meters* recently placed on the market in France are adaptations of his formulae and meter designed as early as 1886. The drawing shows his piezometric meter with density compensator, based on the formula for the output of a fluid:

$$H = 3600\, mS \sqrt{2g\,(p_0 - p_1)} \times \sqrt{\gamma_o}$$

where mS is the area of the orifice, p_0-p_1 fall in pressure, not above 0.1 of the initial pressure p_0, and γ the density of the fluid. The correctness of this formula for gases has been proved by J. Bousinesq (Comptes rendus, t. 138).

UNTERSUCHUNGEN AN ELEKTRISCH UND MIT DAMPF BETRIEBENEN FÖRDERMASCHINEN. *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, vols. 110 and 111. 104 pp., 105 figs., 2 tables. *aA.* A detailed investigation of the comparative cost and efficiency of *steam and electric drive for winding engines.* The general conclusion is that in selecting a system of drive there must be taken into account other conditions than cost, and the system of driving the winding engines must fit in with the rest of the equipment of the mine.

TURBO-KESSELSPEISEPUMPE, *Zeits. für Dampfkessel und Maschinenbetrieb*, December 29, 1911. 4 pp., 3 figs. *b.* Description of, and data on, a *turbine-driven feedwater pump* built by the German General Electric Company.

UNTERSUCHUNG EINES GERISSENEN FLAMMROHRSCHUSSES, E. Heyn and O. Bauer. *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, vol. 112. 22 pp., 36 figs. *cA.* Investigation of the causes why a *flue ring* broke in a boiler. The tests were made at the Royal Laboratory at Gross-Lichterfelde-West for a private concern, and show the method of work at that laboratory, and the thoroughness of it.

VERDAMPFUNGSVERSUCH AN EINEM RAUCHGASVORWÄRMER (EKONOMISER) Bauart Schultz D. R. P., Georg Lehmamn. *Zeits. für Dampfkessel und Maschinenbetrieb*, January 12, 1912. 2 pp. *c.* Data of evaporation test with a *Schultz economiser* made in 1911 in a brewery in Glogau, Germany. Table 1 gives the main data of these tests, compared with the data of tests made in 1910 by the Bavarian Association for the Inspection of Boilers, on a Green, a Düsseldorf, and a Krüger economiser. (Cp. Zeit für Dampfkessel und Maschinenbetrieb, February 16, 1912.)

TABLE I DATA OF ECONOMIZER TESTS

	Green	Düsseldorf	Kruger	Schultz	
	Mean of Seven Tests			Test 1	Test 2
Surface of the feed-heater, qm.	48.2	48.2	48.2	40	40
sq. ft.	518	518	518	430	430
Water evaporated per hour, kg.	1128	1148	1150	2042	1510
lb.	2480	2525	2530	4500	3320
Temperature of water t_1 at entering the feed-heater, deg. cent.	35.5	37.3	37.6	55	47.5
deg. fahr.	95.9	99.2	99.6	131	117.5
Temperature of water t_2 at leaving feed-heater, deg. cent.	105.7	105.7	105.9	130.7	138.3
deg. fahr.	222.3	222.3	222.6	267.3	281
Temperature of main flue gases T_1 at entrance in feed-heater, deg. cent.	228	234	225	436	384
deg. fahr.	442.4	453.2	437	817	723
Temperature of main flue gases T_2 at leaving feed-heater, deg. cent.	164	161	171	203	207
deg. fahr.	327.2	321.8	339.8	397.4	404.6
Carbon dioxide in the gases at entering feed-heater, per cent.	6.2	6.2	5.9	10.28	8.55
Coefficient of heat transmission k.	11.05	13.37	11.63	17.05	16.94
Heat taken up by feed-heater in WE per qm.	1468	1580	1585	3865	3437.8
B.t.u. per sq. ft.	543	585	587	1430	1271

QUELQUES SURCHAUFFEURS. *Revue de mécanique*, December, 1911. 32 pp., 46 figs. *b.* Description of *superheaters*, mainly British and American types, which appeared on the market during the last three years, with a list of articles on superheaters in the Revue de mécanique during the last fifteen years covering practically every patent during that time.

La turbo-soufflante (système Rateau) des hauts fourneaux de Vizcaya, A. Rateau. *La Technique moderne*, January, 1912. 3 pp., 3 figs. *b.* Description of a *Rateau mixed turbine and blower* installed in a blast furnace plant in Vizcaya, Spain. The same article was printed in German in Zeits. des Österr. Ingenieur- und Architekten-Vereines, October 6, 1911, under the title, Turbogebläse, System Rateau, für die Hochofen von Vizcaya.

De l'alimentation dans les chaufferies, J. Guillaume and A. Turin. *La Revue électrique*, January 12, 26 and February 9, 1912. 6½ pp., 10 figs. *bf.* A rather elementary, but very clear, description of *feeding* in boiler plants, with special regard to central station work. May be useful as a basis for lectures to employees.

Les bourrages métalliques et les bourrages souples. *Fer et Acier*, December, 1911. 2 pp., 2 figs. *b.* General discussion of what conditions a good packing for piston rings must satisfy, with a description of the Zimmermann *self-lubricating packing.* This packing is made of a rope impregnated with the lubricating substance, with a perforated metal ribbon spirally wound around the rope. The purpose of the perforations in the winding is to let the lubricating substance through, while the combination of the rope and metal ribbon around it is claimed to make the packing extremely flexible, and at the same time as strong as metallic packing.

Eine neue selbststätige Vorrichtung zur Bestimmung des Kohlensäuregehaltes in Rauchgasen, Ernst Müller. *Zeits. des Vereines deutscher Ingenieure*, December 30, 1911. 3½ pp., 7 figs. *b.* Describes a new apparatus for measuring the *contents of carbon dioxide* in gases of combustion based on the measurement of heat produced by the absorption of carbon dioxide by solution of caustic potash. The rise of temperature is recorded thermoelectrically, and the contents of carbon dioxide can be read directly.

Séparation de l'huile des eaux de condensation par l'électrolyse. Électro, December, 1911. 2 pp., 3 figs. *b.* The Halvor Breda process for *separating the oil from the water of condensation* is based on the property of the electric current to destroy, in passing through water, the oil emulsion, and to assemble the oil particles into flakes which can be mechanically separated from the water. A certain number of iron plates placed in a wooden vessel serve as electrodes; the water of condensation is made to flow between these electrodes, and the current passing through it destroys the emulsion, and drives the oil particles together into flakes; the water then passes through a gravel filter, and comes out clear and free of oil. The apparatus works automatically, and requires practically no attendance.

Recherches sur l'ébulition dans les générateurs de vapeur, M. Émanaud. *Le Génie Civil*, January 6, 1911. *c.* The purpose of this investigation was to *see how boiling occurs in closed vessels with metal surfaces of evaporation.* A Papin digester was constructed with two peep-holes, 60 mm. (2.36 in.) in diameter, covered by chrome glass 10 mm. (0.39 in.) thick, and provided with a safety valve, air escape cock, and manometer. The bottom of the digester was in the form of a truncated cone high enough for the top of the trunk to be conveniently observed through the peep hole. Except for the surface of evaporation the interior of the digester was enameled to prevent oxidation of the walls, and coloring of the water that it would lead to. The digester was heated by a Bunsen burner placed below it, and covered with non-conducting material to prevent heat losses. It was supposed to contain 12 kg. (26.4 lb.).

Boiling in a Closed Vessel. When water is heated in this apparatus with the air escape cock open, boiling begins at about 100 deg. cent. (212 deg. fahr.) ; then, with the air escape cock closed, the *boiling continues* with the temperature rising as the pressure rises, contrary to what books on physics tell. The boiling goes on with greater intensity as the heating is made stronger, and the digester is less protected from heat losses. The author explains it by the supposition that the temperature is not uniform throughout the mass of the water, and that there is no real correspondence beween the tension at the free surface of the liquid and its temperature. As regards steam generators this shows that internal circulation may start as soon as the whole mass of the water has reached a temperature in the neighborhood of 100 deg. cent. (212 deg. fahr.), and there is an internal circulation, slow but real, during stops and periods of raising the pressure, a fact that may be of interest for heating of boilers, especially those which do not have free expansion.

Size of Steam Bubbles. For a good circulation the steam bubbles must be small. Observation has shown that the size of the bubbles depends on the nature of the liquid and surface of evaporation, and on the regularity of the process of boiling. When pure water is boiled over a clean metal surface, the bubbles are remarkably uniform in size, while in a carefully cleaned glass flask, where ebullition is difficult, both large and small bubbles appear. With given conditions of ebullition, the size of the bubbles appears to be independent of the pressure, but increases with the demand for vapor, or rate of evaporation, or, what amounts to the same thing, retardation of ebullition, or with the difference between the average temperature of water at the contact with the surface of evaporation and the temperature for which the manometric pressure would correspond to the maximum tension of saturated vapor. As regards the absolute dimensions of the bubbles, in pure water boiling over clean metallic surfaces, the bubbles are very small; about 1 mm. (0.039 in.) in diameter. But a very thin layer of graphite grease or oil on the surface of evaporation produces at once an approximately five-fold increase in the size of the bubbles. Pure graphite in flakes does not produce this result.

Formation of Bubbles. The formation of bubbles depends on the state of capillary equilibrium between the liquid, the vapor and the surface of evaporation. Thus, if a part of the surface of evaporation is polished, no vapor bubbles are formed on that part, although boiling goes on around it. The author explains it by the supposition that a higher temperature is necessary to produce boiling on a polished surface. If, instead of water, a solution of some calcium salt is heated, which easily gives a precipitate, the nature of the surface is modified, and boiling goes on in a regular manner, i. e., all over the surface. That probably explains why marine boilers using sea water steam worse when new.

The author recommends the use of the apparatus described for the study of the action of materials recommended for the prevention of scale and of paints intended for the prevention of corrosion of boiler plates. The apparatus does not appear to have been patented.

Déshuileur de vapeur d'échappement système Massip. *La Revue électrique*, January 26, 1912. 1 pp., 3 figs. *b.* Description of an *oil separator for exhaust steam*, Massip system. The stream of steam is divided into very thin layers by two groups of fixed curved partitions, all of the same curvature, and at equal distances from each other. These partitions are provided with vertical projections, with grooves at the bottom, and the particles of oil striking against these projections are stopped by them, and are finally forced to flow along the grooves and out of the apparatus.

Tests made at the central station of the Paris Gas Company at Landy have shown that, when installed with two 650-h. p. engines, the oil separator produced a loss of pressure of 115 mm. (4.4 in.) of water, and that the water of condensation contained only 1.5 mg. of oil per liter coming from the apparatus, against 500 mg. per liter which it had on entering.

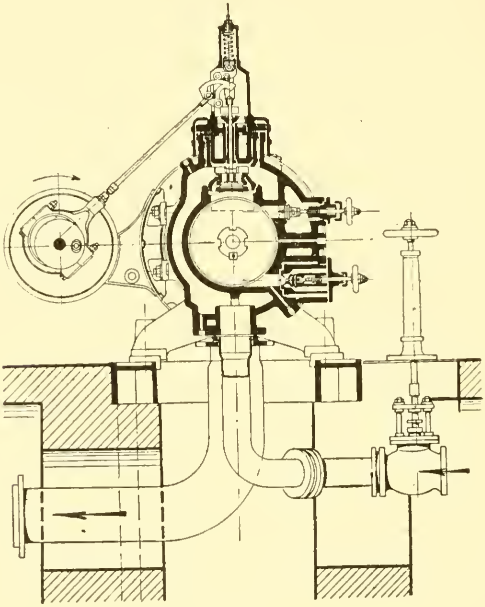

Fig. 6 Straight-Flow Steam Engine, Arrangement of Valves

Ergebnisse der Abnahmeversuche einer Z-M.-Gleichstrom-Dampfmaschine, Karl Benecke. *Zeits. für Dampfkessel und Maschinenbetrieb*, December 15, 1911. The tests were made by the Saxony (Germany) Association for the Inspection of Boilers. The machine under test was a 380-h.p. straight-flow steam engine having the dimensions:

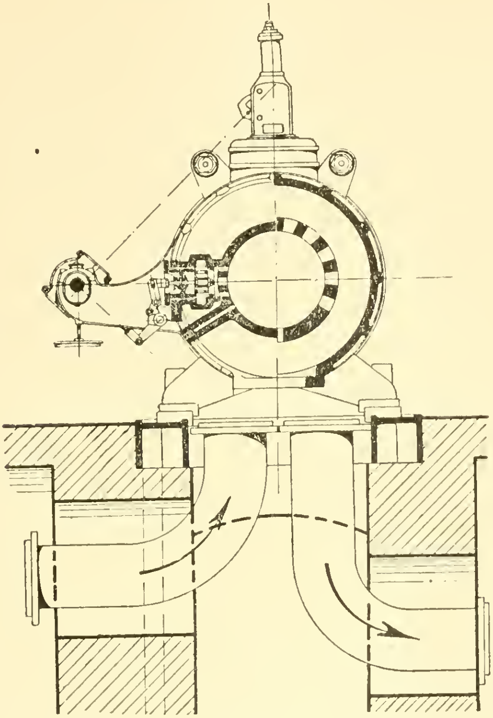

Fig. 7 Straight-Flow Steam Engine Auxiliary Exhaust Gear

	Crank side.	Cover side.
Cylinder diameter, cold measured mm. in.....	720/28.3	720/28.3
Cylinder diameter, hot, calculated mm........	720.9	720.9
Piston-rod diameter, mm./in................	142/5.59	140/5.51
Piston working area F, qcm./sq. in..........	3921.293/607.75	3925.723/608.4
Stroke s, mm./in..........................	900/35.43	900/35.43
Constant $\frac{F.s.}{60.75}$	0.78426	0.80737
Sum for both sides of the piston....................	1.59163	
Volume swept by piston per stroke, l/cu. ft..........	353.11	353.51
Average volume swept by piston per stroke, l/cu. ft...	353.31	
Ratio of cylinder volumes.........................	1	
Clearance, l....................................	8.47	9.19
$\frac{\text{Clearance}}{\text{Volume swept by piston per stroke}}$ per cent............	2.4	2.6
Average clearance, l..............................	8.83	

The general arrangement of the valve gear is shown in Fig. 6. It is built on the principle of the Lentz or Proell valve gear, with the difference that the cam opening the valve does not act directly on the pulley connected with the valve stem, but an intermediate lever is inserted. This eliminates the considerable side pressures of the Lentz valve gear.

Fig. 7 shows the novel arrangement of the auxiliary exhaust gear. Prof. Stumpf in his book, Die Gleichstrom-Dampfmaschine (1911, p. 49), states that each condensing, straight-flow steam engine should be provided with a reserve clearance space, in order to facilitate the starting of the engine in case the condensor pump is out of commission, and to make possible the work of the engine without condensation. Experiments made by the Zwickauer Maschinenfabrik have shown that increase of clearances in non-condensing steam engines leads to considerably increased consumption of steam, and is, therefore, not economical (the article contains data of one of these experiments). The principle of the auxiliary exhaust gear shown in Fig. 4 consists in placing at the ends of the cylinders two auxiliary exhaust valves actuated by a separate eccentric, and arranged so that their cycle of action can be set in accordance with the steam pressures and temperatures. The driving eccentric transmits by means of a link its motion to an intermediate shaft carrying the cranks acting on the auxiliary exhaust valves. In passing from working condensing to working non-condensing and *vice versa* all that is necessary is to throw in or out this link. In the last type this link is connected with the wheel of the two-way valve in such a manner that when the engine is set for working non-condensing, the auxiliary exhaust gear is cut in. The results of the test are given in the following tabulation:

Beginning of test		9 hr. 33 min.
End of test		3 hr. 58 min.
Duration of test		6 hr. 25 min.
R. p. m.		106.37
Average piston speed, in. per sec.		3.191
Steam pressure above atmosphere:		
in boiler	kg/qcm	10.25
	lb. per sq. in	145.75
at boiler side of stop valve	kg/qcm	9.8
	lb. per sq. in	139.35
at entrance to steam cylinder:		
crank side	kg/qcm	9.8
	lb. per sq. in	139.35
cover side	kg/qcm	7.9
	lb. per sq. in	112.34
Temperature of steam:		
at superheater, cent./fahr.		207.5/405.5
at entrance to engine, cent./fahr		118/370.4
superheat, cent./fahr		6/10.8
Cut-off (cylinder), per cent		about 6.5
Vacuum:		
maximum value in diagram	kg/qcm	0.88
	lb. per sq. in	12.53
in condenser, cm./in		66.9/26.5
Water and air:		
temperature of condenser injection water, cent./fahr		17/62.6
temperature of condenser return water, cent./fahr		33/91.4
barometric pressure of air, kg/qcm/lb. per sq. in		1.005/14.29

Power:		
total power, i.h.p		324.68
cylinder	crank side	181.69
	cover side	142.99
average indicated pressure, crank side	kg/qcm	2.178
	lb. per sq. in	30.97
average indicated pressure, cover side	kg/qcm	1.665
	lb. per sq. in	23.60
*Steam consumption:		
total consumption of feedwater, kg./lb		12777/28109
consumption of water per hour, kg./lb		1991.16/4380
consumption of steam per h.p.-hr. apart from water of condensation from steam supply	kg	6.13
	lb. per h.p	15.4
*Heat account:		
total heat of saturated steam entering engine, WE per kg./B.t.u. per lb.		666.9/1200.4
total heat of superheated steam entering engine, WE per kg./B.t.u. per lb.		660.4/1188.7
heat of steam consumed per h.p-hr, WE per kg./B.t.u. per lb.		4109.6/7397.3

OBSERVATIONS ET FORMULES RELATIVES A L'ÉCOULEMENT DES FLUIDES ÉLASTIQUES, Maurice Leblanc. *La lumière électrique,* December 16, 1911; January 20, 1912. *ch.* A jet of steam was propelled from a nozzle into a diffuser (and condenser), the jet passing on the way through a closed vessel where a high vacuum was maintained. The vessel was lighted, and a peep-hole provided to permit inspecting the interior. If the steam was dried in a separator, the jet was invisible; if not, the jet was opaque. The jet was introduced at a pressure of 6 kg/qcm (85 lb. per sq. in.), the nozzle arranged to expand it to 2 mm. of mercury, while the pressure in the vessel was only 1 mm. of mercury.

The opaque jet of wet steam had the appearance of a rigid rod, at first cylindrical, but drawn out to a point as it penetrated into the diffuser where the pressure increased gradually and directly as the distance from the entrance (Fig. 8). This drawing out was observed only inside the diffuser, while between the outlet of the nozzle and the entrance of the diffuser the jet appeared to be cylindrical, showing that the contraction observed is real, due to the increase of pressure, and not merely apparent, as would have been the case if the superheating of the steam was caused only by friction.

There was another striking phenomenon: large drops of water which fell from the top of the vessel on the jet did not pass through it, and were not carried with it, but rebounded from it as if they had struck an iron rod. The density of the jet was about 900,000 times less than that of the water drops, but the velocity of translation of the fluid was at least 1300 m. (4265 ft.) per min. The same happened when the steam was dry and the jet invisible; the drops of water were not carried away by the jet, but glided along it as if it were an iron rod, and when the jet was let into an exhausted glass bell, the jet could not be seen, but, on looking through the bottom, a circle formed by the projections of the water drops was plainly visible.

When a fluid jet suddenly passes from a medium at a higher to one at a lower pressure, the different stream lines of the jet do not diverge all the time and form a sort of a cone, as one would expect. The jet, after several expansions and contractions, rapidly recovers its cylindrical form, and the stream lines get close together again, there being a tendency in the jet to have at each moment the smallest cross section possible. The jet acts as if it were encased in an elastic sheath, or as if its surface were subject to surface tension. It seems to the author therefore that a jet having a great velocity, *has an individuality of its own, and is always clearly distinct from the surrounding medium*, even if it be solid walls of a passage through which the jet flows. In general, the limiting surface of the jet is different from that of the enclosing passage, and there is a ring of eddies between them. The author concludes: (*a*) at all points of a section normal to the axis the pressure as well as the velocity of the separate stream lines in the fluid remain practically constant with a slight increase towards the center. One can apply to it the hypothesis of layers and the formula of Saint-Venant,[1] provided the layers are limited by the surface of the jet, and not by the walls of the passage through which the jet flows; (*b*) the friction at the surface of the jet is small if it is exerted against a fluid at rest, or against a smooth metal surface, but becomes considerable when the fluid has a velocity of translation comparable to that of the jet, and especially if it eddies around it. The author proceeds to prove, from the formulæ of Saint-Venant and Weisbach,[1] that when a fluid jet passes from a medium at a certain pressure P_1 to another medium at an inferior pressure P_2, it contracts as long as the velocity of the fluid is less than that of sound, and begins to expand as soon as its velocity exceeds that of sound, the velocity of the jet being greater than that of sound when the ratio $\frac{P_2}{P_1}$ is less than $\left(\frac{2}{1+\alpha}\right)^{\frac{\alpha}{\alpha-1}}$. The exponent α in the adiabatic equation $PV^{\alpha}=\text{constant}$ is constant for each fluid, but variable from one fluid to another. It follows from this

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* Correction for the difference between American and German horsepower has been made in Steam consumption and Heat account.

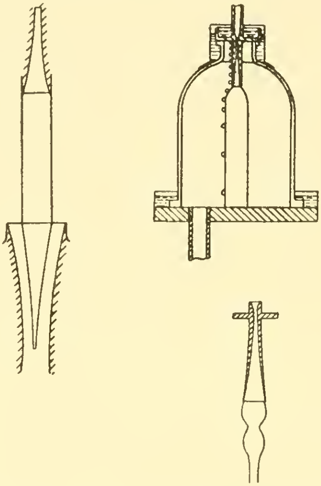

FIG. 8 STEAM JET IN EXHAUSTED VESSEL AND DIFFUSER; BEHAVIOR OF WATER DROPS TOWARDS STEAM JET; CHANGE OF FORM OF JET WITH CHANGE OF PRESSURE

that when the ratio of expansion $\frac{P^2}{P_1}$ is greater than $\left(\frac{2}{1+\alpha}\right)^{\frac{\alpha}{\alpha-1}}$, or than $\frac{P}{P_1}$, where p is the pressure at the minimum of cross-section, the nozzle must be simply converging; if it is less, the nozzle must be converging-diverging. For air this ratio[1] is 0.526, and for saturated dry steam, at the beginning of expansion, it is (according to Zeuner $\alpha=1.135$) 0.580. If the steam is wet at the beginning, and its quality is x, then

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[1] For Saint-Venant's formula see H. H. Suplee, The Gas Turbine, 1910, p. 181. Formula (5) on the same page is Weisbach's formula.

x	α	$\frac{P}{P_1}$
1	1.135	0.5774
0.9	1.125	0.5795
0.8	1.115	0.5815
0.7	1.103	0.5840

the values of α being determined by the empirical formula valid for x between 0.7 and 1

$$\alpha=1.035+0.100x$$

Determination of the Smallest Cross-Section of a Nozzle for a given Output. The inlet opening of a nozzle may be as large as possible, but the outlet opening in a converging nozzle, or the "neck" of the converging-diverging nozzle have to be of definite dimensions to give a given output at maximum efficiency. The nozzle is supposed to have exactly the form of the jet.

Converging Nozzles. A fluid having a specific weight ω, at pressure P_1 (i. e. 1 cu. m. of the fluid at pressure P_1 weighs ω kg.) flows through a converging nozzle into a space having a pressure P_2 smaller than P_1 but greater than

$$P_1\left(\frac{2}{1+\alpha}\right)^{\frac{\alpha}{\alpha-1}}$$

both pressures being in kg. per sq. cm. (to convert them into lb. per sq. in. multiply by 14.22); the output, in grams per sec. per sq. cm. of the section of the opening, is given by the formula

$$J=10\left(\frac{P_2}{P_1}\right)^{\frac{1}{\alpha}}\sqrt{\frac{2g\alpha}{\alpha-1}\,\omega_1 P_1\left[1-\left(\frac{P_2}{P_1}\right)^{\frac{\alpha-1}{\alpha}}\right]}$$

and the efflux velocity of the fluid in the outlet is, in meters per second

$$W_2=100\sqrt{\frac{2g\alpha}{\alpha-1}\,\frac{P_1}{\omega_1}\left[1-\left(\frac{P_2}{P_1}\right)^{\frac{\alpha-1}{\alpha}}\right]}$$

These formulae are applicable only to homogeneous fluids, and do not generally hold good for a mixture of steam and water.

Converging-Diverging Nozzles. The output of such a nozzle depends only on the initial pressure P_1, since P_2 must be less than p, or there would be no need for using such a nozzle.

Longitudinal Section of a Diverging Nozzle. The angle of cone of the nozzle was often made constant. This can be done in steam turbines, where the steam is not expanded beyond a certain limit, but would require the use of inconveniently long and very wasteful nozzles in the ejectors of the refrigerating machinery where the expansion is carried to a very high degree. It is therefore well to know how to determine the most efficient longitudinal section of a diverging nozzle.

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[1] L. Sekutowicz (Mémoires de la Société des Ingénieurs Civils de France, 1906, p. 268) gives this ratio as 0.529.

If the radius of a section of the nozzle normal to the axis at a distance x from the beginning be denoted by R, then the tangent of its angle of cone is $\frac{dR}{dx}$ From Saint-Venant's formula the author obtains the following equation:

$$\frac{dP}{dx}=\frac{P\alpha W^2}{R}\,\frac{\left[\eta-2\frac{dR}{dx}\right]}{W^2-W_s^2}$$

where W is the velocity of flow of steam, W_s the velocity of sound, and η a constant coefficient. This shows that in order to have

$$\frac{dP}{dx}<0$$

when W is greater than W_s, it is necessary that

$$\frac{dR}{dx}>\frac{\eta}{2}$$

or, in other words, *the angle of cone* of a nozzle *must be the greater, the greater the coefficient of friction of the fluid against the walls of the nozzle.*

Leblanc has adopted the following rule for the design of the nozzles in his ejectors: the angle of cone which is at first, at the neck of the nozzle, equal to zero, changes rapidly until it becomes equal to 6 deg. It then remains constant until the steam attains the temperature corresponding to the pressure in the condenser into which the ejector opens; then the angle gradually grows up to the outlet orifice. The curvature of the walls of the nozzle is such that, in a section normal to the axis, the pressure is 10 per cent less at the periphery than at the centre.

In the following number will be given a description of the Leblanc refrigerating machine (Cp. Mémoires de la Société des Ingénieurs Civils de France, November, 1911, and Bulletin de la Société d'Encouragement pour l'Industrie Nationale, December, 1911).

Strength of Materials and Materials of Construction

Kautschuk und seine technische Prüfung, K. Memmler. *Gummi-Zeitung*, January 12, 1912. 4 pp., 7 figs. *f.* Discusses methods of testing rubber, mainly on the basis of the practice of the German Royal Testing Laboratory at Grosz-Lichterfelde-West. It was found that tests for tensile strength with rubber bars placed in the grips of a testing machine in the way steel bars are placed gave quite unreliable results, and that a much better way was to punch or turn out a rubber ring with a rectangular cross section, place it belt-like over two pulleys, and draw the pulleys apart. For fuller account of the work done by the laboratory on rubber testing cp. *The India Rubber Journal*, November 25, December 2, 9, 1911.

Über Schalldurchlässigkeit. *Tonindustrie-Zeitung*, January 23, 1912. ½ p. *h.* Account of an investigation of *sound conductivity* of different materials by R. Berger in Munich. The first part of the investigation covers the problem of subjective and objective measurement of sound. In the second part Mr. Berger investigates mathematically the propagation of sound and its conduction in various bodies, showing, among other things, that to prevent the propagation of sound in one body another body must be used as an isolator, for which the product of thickness and velocity of propagation of sound is as much as possible different from that for the first body; telephone booths ought therefore to be lined with iron sheets, and not with felt. In the third part the influence of the material in walls on conductivity of sound is treated. Felt, carpets, etc., are good sound absorbers and poor conductors of sounds produced in the material itself, but easily convey sounds produced in the air. A reinforced concrete wall, on the contrary, is a poor conductor for sounds produced in the air, but will transmit through several floors the sound produced by hitting the wall with a hammer. Mr. Berger attaches considerable importance to the distinction between sound produced in the air and in the material itself.

De l'acier fabriqué au four électrique. *Journal du four électrique*, January 15, 1912. 1 p. *f*. From a paper by Mr. Rodenhauser before the Chemical Association of Freiberg.

TABLE 2 COMPARISON OF STRENGTH OF BESSEMER AND ELECTRIC FURNACE STEEL

	Tensile Strength	Elongation, Per Cent	Limit of Elasticity	Reduction of Area, Per Cent
Bessemer Steel..........	38 to 44 kg. 84 to 97 lb.	22 to 24	28 kg. 62 lb.	50
Electric Steel (Koehling).	61 to 65 kg. 134 to 143 lb.	17 to 18.6	41.6 to 45.4 kg. 91.5 to 100 lb.	43.6 to 52

Versuche mit Aluminum geschweiszt und ungeschweiszt, bei gewöhnlicher und höherer Temperatur, R. Baumann. *Zeits. des Vereines deutscher Ingenieure*, December 12. The experiments were made with aluminum bars containing not less than 99 per cent pure aluminum; part of the bars were annealed and hammered, part welded, annealed and hammered, and part not annealed (Table 3).

At ordinary temperatures, tests for elasticity have shown that elongation and tension remain proportional to each other up to the following loads:

For annealed and hammered bars, 159 kg/qcm (2260 lb. per sq. in.)

For a bar which has been subjected before the test to a pressure of about 2500 kg/qcm (35551 lb. per sq. in.) 168 kg/qcm (2389 lb. per sq. in.).

Experiments for the determination of tensile strength, elongation at rupture, and reduction of area at ordinary and higher temperatures. The tensile strength decreases considerably and steadily as the temperature rises; cold rolled material shows even at higher temperatures a greater tensile strength than annealed and hammered bars; welded bars have a

TABLE 3 TEST OF STRENGTH OF ALUMINUM BARS

Thickness of Bar Mm. In.	Length of Bar Mm. In.	Annealed and Hammered Bars					Welded, Annealed and Hammered Bars				Unannealed Bars			
		Temperature, Deg.					Temperature, Deg.				Temperature, Deg.			
		Cent. 20 Fahr. 68	Cent. 60 Fahr. 140	Cent. 100 Fahr. 212	Cent. 200 Fahr. 392	Cent. 300 Fahr. 572	Cent. 20 Fahr. 68	Cent. 100 Fahr. 212	Cent. 200 Fahr. 392	Cent. 300 Fahr. 572	Cent. 20 Fahr. 68	Cent. 100 Fahr. 212	Cent. 200 Fahr. 392	Cent. 300 Fahr. 572
		Tension at Rupture in Kg/qcm—Lb. per Sq. In.												
17 0.668		927 13182		677 9627	384 5460	241 3427	1040 14788	760 10807	439 6243	305 4337	1506 21415	739 10508	471 6697	284 4024
12 0.472							1059 15059	845 12015	546 7764	330 4793				
8 0.314		1045 14860	884 12570	738 10494	397 5645	206 2929	1018 14480	764 10864	627 8916	266 3983	1417 20150	1230 17490	834 11859	315 4479
4 0.157		1016 14448		666 9470	482 6854	261 3711	1014 14419	755 10736	523 7437	286 4109	1270 18059	915 13011	644 9158	301 4280
		Elongation at Rupture, Per Cent												
17 0.668	50 1.968	53.8		79.2	92.8	(119.2)	40.4	(63.0)	65.8	(49.0)	14.5	61.1	78.0	81.2
	100 3.937	41.6		61.5	65.5	(87.0)	26.0	(49.4)	38.9	(24.0)	8.6	46.0	58.9	53.5
	200 7.874	33.5		51.4	47.7	(63.1)	18.9	(33.1)	20.0	(13.0)	5.1	37.2	46.5	39.6
8 0.314	60 2.362	38.6	49.9	61.3	78.0	70.8	25.2	41.7		(26.7)	11.8	16.3	20.8	48.8
	120 4.724	31.1	38.3	49.6	61.4	54.3	16.6	27.7		(17.1)	7.1	9.2	13.2	30.3
		Reduction of Area, Per Cent												
17 0.668		66.0		80.5	90.3	95.0	53.8	70.8	86.0	(68.6)	30.8	76.3	85.9	90.3
12 0.472														
8 0.314		65.9	71.9	75.0	84.4	88.9	63.5	78.0		83.8	50.9	53.0	68.1	81.4
4 0.157.		90.8		74.4	86.8	94.6	55.0	69.5	79.8	92.3	49.4	68.8	76.9	79.5

higher tensile strength than annealed and hammered bars; there are, for the most part, no gaps at the welded places on the surface of rupture; welded bars have lower values for, and slighter increases of, elongations with the increase of temperature than bars not welded; the reduction of area increases with the temperature, and reaches extremely high values. The coefficient of hardness by Brinnell's method (load 500 kg., diameter of the ball 10 mm.) was found to be for unannealed bars 17 mm. (0.68 in.) thick, between 23.9 and 44.6 kg. per qmm. (33,985 to 63,421 lb. per sq. in.); for annealed bars of the same thickness 26.2 (37,256 lb. per sq. in.), and for welded bars 31.8 (45,220 lb. per sq. in.). Previous heating to 300 deg. cent. (572 deg. fahr.) reduced the hardness of annealed bars to 24.7 kg. per qmm. (35,023 lb. per sq. in.), that of welded bars to 27.5 (39,305 lb. per sq. in.), while the hardness of unannealed bars was found to be 23.5 (31,617 lb. per sq. in.).

For a notch shock test a groove of 1.3 mm. (0.0516 in.) in diameter cut along the flange served as a notch; the surface distance was 70 mm. (2.8 in.), cross-section 10 mm. x 5 mm. (0.0775 sq. in.). Annealed and hammered aluminum required for rupture a work of 4.3 mkg/qcm (200 ft.-lb. per sq. in), without a complete rupture of the bar taking place. A welded bar required a work of 3.7 mkg/qcm (172 ft.-lb. per sq. in.), and did not break completely, while the unannealed piece broke after 1.5 mkg/qcm (70 ft.-lb. per sq. in.).

Einfluss der Umschmelzung und Abkühlung auf die chemischen und mechanischen Eigenschaften von Lagermetallen, G. Goldberg. *Giesserei-Zeitung*, January 15, 1912. 2 pp. *c.* An account of tests made at the Royal Laboratory at Gross-Lichterfelde-West to determine how repeated melting, heating and cooling affects the chemical constituency and mechanical properties of *bearing-metal alloys.* It was found that repeated melting does not make substantial changes in the chemical composition of *white-metal:* the percentage of copper in the alloy increases by about 0.2 of 1 per cent. for each melting, but the ratio of tin and antimony remains the same, although the absolute percentage of these metals in the alloys decreased by about 1.4 per cent. after five meltings. It was further found that when white-metal is heated and then cooled, its mechanical strength is favorably affected by rapid cooling, and decreased by slow cooling: slowly cooled metal is about 10 per cent. weaker in compression than rapidly cooled, while in the upsetting test a work of 2.5 mkg/qcm (115 ft. lb. per sq. in.) was applied when cracks appeared in slowly cooled metal, and 13.75 mkg/qcm (633 ft. lb. per sq. in.) in rapidly cooled metal. The chemical composition of *gun-metal* alloys was affected by repeated meltings in the same way as that of white-metal, but its strength and elasticity were noticeably weakened by repeated meltings. The article is to be continued.

Neue Versuche über die Feuersicherheit des Eisenbetons, R. Saliger. *Tonindustrie-Zeitung*, January 13, 1912. 1½ pp. *c.* Describes experiments made at the Technical Institute in Berlin on *reinforced concrete as a fire resisting material.* Two little houses, 6 m. (about 20 ft.) long and 4 m. (about 13 ft.) broad and high, were built, filled with wood and set on fire. In one house the reinforcing elements were embedded 0.5 cm. (0.196 in.) deep, in another 2 cm. (0.78 in.) deep, the houses being built partly of gravel concrete, partly of limestone ballast concrete. The fire was kept burning for 2 hours 20 minutes. The plastering began to fall off 4 minutes after the fire was started, when the temperature was still below 100 deg. cent. (212 deg. fahr.), thus showing its total uselessness. The difference in the depth of embedding the reinforcing elements did not appear to affect the strength of the wall. On the whole, ballast concrete was found to be stronger and more fireproof than gravel concrete, and from the behavior of both a general conclusion could be drawn, that the thickness of the walls must not go below a certain minimum if it is desired to prevent them from crumbling during a fire. The article gives detailed data on the bending of the walls, change of elasticity of concrete due to the heat, and the arrangement of measuring instruments for this experiment.

Holzbandrohren, ein neues Baumaterial für Luftfahrzeuge. *Zeits. für Flugtechnik und Motorluftschiffahrt*, January 27, 1912. 1 p., 4 figs. *b*. Wood is not a uniform material, but consists of rings, some hard and strong, and some weak and soft. The soft rings are hygroscopic, easily affected by heat and chemical changes, and form generally the weakest part of a wood piece; it is their presence that produces the warping of wood boards. In the *Mutter system of producing wooden tubes* the hard rings are carefully split off from the piece, bent into rings, and joined together until they form a cylindrical body. Other pieces are then wound around the cylinder at an angle to the generating line, the purpose of these pieces being to take up the torsional stresses. The whole is said to form a light and extremely strong tube.

Thermodynamics

Etude de la transmission de la chaleur entre un fluide en mouvement et une surface métallique, Leprince-Ringuet. *Revue de mécanique*, July, September, December 1911. The author shows that the *law of exchange of heat between a gas passing through a pipe and the walls of the pipe* can be expressed by the following equation:

$$\alpha = A\ (w\omega)^n = B\ (Cw\omega)^n$$

where α is the quantity of heat transmitted per hour per square meter; w velocity of the gas in meters; ω weight of a cubic meter of gas in kilograms; n an exponent depending on the ratio of the section of passage to the perimeter of exchange For a given fluid, C is a function of the temperature τ, and may be expressed as:

$$C = C_0\ (1 + \delta\tau)$$

The coefficient of transmission depends on the length of the tube, and it may be written

$$B = \frac{B_1}{l^p}$$

where B_1 corresponds to $l = 1$ m. In passing from one fluid to another, the coefficients B and C vary but slightly.

For air the general formula which holds good for pipes from 0.50 to 1.50 m.

(1.6 to 4.9 ft.) long, having a diameter from 0.01 to 0.10 m. (0.39 to 3.9 in.), for temperatures from 0 to 300 deg. cent. (32 to 572 deg. fahr.), may be written:

$$\alpha=\frac{51.5}{l^{\mathrm{p}}}\Big[0.080(1+0.0016\ \overline{\tau-160)}w\omega\Big]^{\mathrm{n}}$$

or

$$\alpha=\frac{51.5}{l^{\mathrm{p}}}\Big[0.0595(1+0.00215\tau)w\omega\Big]^{\mathrm{n}}$$

where n can be generally found from the following experimental formula:

$$n=\frac{1+18d}{1+36d}\dots\dots\dots\dots[1]$$

The author gives a $n=f(d)$ diagram containing curves from his own calculations, from formula [1], and those from the experiments of Nusselt, Jordan and Stanton. The value of p has not yet been exactly determined, but appears to be in the neighborhood of 0.13.

This formula shows that, with a dry gas, the exchange of heat can be considerably increased by increasing the quantity of gas flowing, or the perimeter of contact as compared with the section of passage, or by facilitating the production of eddies inside the pipe. The same formulæ apply to boilers, radiators, etc.

Condensation on the metal surface materially increases the exchange of heat, because the heat liberated by the condensation is set free exactly at the contact with the metal, and easily taken up by it; it is practically equivalent to making the term l^{p} very small or equal to zero, or multiplying the coefficient of transmission by a number from 50 to 100.

NOUVELLES RECHERCHES SUR LA DETENTE ADIABATIQUE DES GAZ ET SUR L'ÉQUIVALENT MÉCANIQUE DE LA CHALEUR, Emile Schwoerer. RAPPORT SUR LE TRAVAIL DE M. SCHWOERER, Roger Hartmann. *Bulletin de la Société industrielle de Mulhouse*, October 1911. 34 pp. *e*. New mathematical investigation of adiabatic expansion of gases and mechanical equivalent of heat.

DER WÄRMEÜBERGANG IM KREUZSTROM, Wilhelm Nuszelt. *Zeits. des Vereines deutscher Ingenieure*, December 2. The exchange of heat in a surface cooler depends on the water values of the liquids flowing through it in unit time, the temperatures of entering liquids, area of cooling surface, coefficient of heat transmission, and relative directions of the paths of the fluids. The article is devoted to the consideration of the last variable, when the two directions of flow are at right angles to each other.

If the two liquids are heated to an amount small as compared with the mean temperatures on both sides of the wall, then the total amount of heat exchanged may be taken, with sufficient approximation, as being proportional to the average difference in temperature between the two liquids. The amount of heat exchanged in unit time is then

$$Q=\frac{T_1-t_1}{\frac{1}{KF}+\frac{1}{2W}+\frac{1}{2w}}$$

where T_1 and t_1 are the temperatures of the entering liquids, W and w water equivalents of the liquids passing through the apparatus in unit time, F area of the cooling surface, and K coefficient of heat transmission. If, however, the change of temperature of the liquid is great, the above formula has to be replaced by the equations deduced below.

Most of the surface coolers can be considered as devices consisting essentially of a rectangular cooling surface along which flow the liquids in a thin layer. The particles of each liquid may be considered to flow with equal velocities along parallel paths, while their directions of flow are at right angles to each other. In Fig. 9 the rectangle *ABCD* represents the cooling surface. One liquid, with water equivalent per hour w, flows along the surface parallel to AB, entering along AD with a constant temperature $t=0$. The other liquid enters with a constant temperature T_0 along the side AB, and flows on the other side of the surface, parallel to AD. Let the temperature of this liquid at the point x, y, be T, that of the first liquid at the same place t. If we consider at that place a rectangular element with the sides dx and dy, then in unit time to the cooling liquid will be transferred the amount of heat

$$dQ = Kdxdy(T-t)$$

The fall of temperature of the hot liquid will be equal to partial differential $\frac{\delta T}{\delta y}dy$, according to the equation $dQ = -\frac{W}{x_0}\frac{\delta T}{\delta y}dxdy$, while the rise of temperature of the cooling liquid will be $\frac{\delta t}{\delta x}dx$, corresponding to the equation $dQ = \frac{\delta t}{\delta x}\frac{w}{y_0}dxdy$.

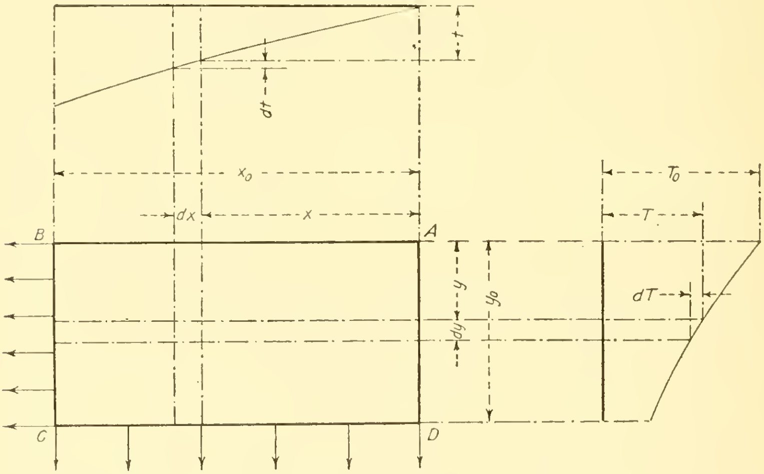

Fig. 9 Diagram of Flow of Liquids in Surface Cooler

By equating these quantities of heat to each other, we obtain the two temperatures expressed by the following partial differental equations:

$$\frac{W}{x_0}\frac{\delta T}{\delta y} = \frac{w}{y_0}\frac{\delta t}{\delta x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1$$

$$K(T-t) = -\frac{W}{x_0}\frac{\delta T}{\delta y} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [2]$$

By partially differentiating the second equation in x, and substituting in the result obtained for $\frac{\delta t}{\delta x}$ its value from the first equation, we obtain an equation containing only T

$$\frac{\delta^2 T}{\delta x \delta y}+\frac{Kx_0}{W}\frac{\delta T}{\delta x}+\frac{Ky_0}{w}\frac{\delta T}{\delta y}=0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots [3]$$

This equation allows to calculate the path of temperatures over the surface $ABCD$, since for $y=0$, $T=T_0$, and for $x=0$, $t=0$. If we insert this value of t in equation [2], we obtain $KT=-\frac{W}{x_0}\frac{dT}{dy}$, which when integrated, gives

$$|T|_{x=o}=T_0 e^{-\frac{Kx_0}{W}y}=T_0 e^{-\frac{KFy}{Wy_0}} \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

When T is found, t may be obtained from equation [2] by integration. The values of T and t are as follows:

$$T=T_0 e^{-\frac{KF}{W}\frac{y}{y_0}}\left[1+\int_0^{\frac{K^2F^2}{Ww}\frac{xy}{x_0y_0}} \frac{iJ_1(2i\sqrt{z})}{\sqrt{z}} e^{-\frac{Wy_0}{KFy}z} dz\right] \ldots\ldots\ldots [5]$$

$$t=\frac{T_0 e^{-\frac{KF}{W}\frac{y}{y_0}}}{\frac{KF}{W}\frac{y}{y_0}}\int_0^{\frac{K^2F^2}{Ww}\frac{xy}{x_0y_0}} J_0(2i\sqrt{z})\, e^{-\frac{Wy_0}{KFy}z} dz \ldots\ldots\ldots\ldots [6]$$

J_0 and J_1 are Bessel functions of zero and first order. The author gives a table of values of these functions, which can, however, be found in Jahnke und Emde: Funktionentafeln.

The amount of heat exchanged can be found either from the degree of cooling of one liquid, or from that of heating of the other. The cooled liquid leaves the apparatus along the edge $y=y_0$. Its temperature at leaving is

$$T_{y=y_0}=T_0 e^{-\frac{KF}{W}}\left[1+\int_0^{\frac{K_2F^2_x}{Wwx_0}} e^{-\frac{W}{KFz}}-\frac{iJ_1(2i\sqrt{z})}{\sqrt{z}} dz\right] \ldots\ldots\ldots [7]$$

and the amount of heat exchanged in unit time is found to be, from the mean temperature,

$$Q=W\left(T_0-\frac{1}{x_0}\int_0^{x_0} T_{y=y_0}\, dx\right) \ldots\ldots\ldots\ldots\ldots [8]$$

The amount of heat exchanged is independent of the ratio $\frac{x_0}{y_0}$ of the cooling surface, and depends only on the area of the surface.

The article contains also an example worked out by the author, and tables and curves for $y=y_0$, T, t, and $T-t$.

Miscellaneous

MATERIALPRÜFUNG IM KÖNIGL. MATERIALPRÜFUNGSAMT. *Zeits. für Dampfkessel und Maschinenbetrieb*, January 26, 1912. 4 pp. *g.* Sketch of the work done during the year 1910 by the Royal Testing Laboratory at Grosz-Lichterfelde-West. Cp. Scientific American, December 30, 1911.

WARUM VERSAGEN DIE BISHER ANGEWENDTEN BITUMINÖSEN SCHUTZHÜLLEN VON EISENROHREN, B. Haas. *Eisen-Zeitung*, December 16, 23, 1911. 2 pp. *f*. *Covering for gas and water pipes* consisting of jute or hemp impregnated with some bituminous substance is inferior to that in which the bituminous substance covers the pipe directly, because the jute or hemp is partly weakened by the heating of the tube previous to impregnation, and, if roughly handled, is easily broken. The bituminous covering is not stable; even if the pipes are kept long above ground, they begin to decompose and give off a certain odor. Disintegration is still more rapid when the pipe is laid in the ground, due to a large extent to the physical and chemical interaction of the iron of the pipe and the bituminous mass of the covering when hot. The author believes that a covering which could be laid on the pipe *cold* would prove preferable.

ABSTRACTS OF ARTICLES

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(XV)

ARTICLES IN PERIODICALS[1]

DIESEL ENGINES, LARGE RUSSIAN VESSELS PROPELLED BY, J. Rendell Wilson. *International Marine Engineering*, January 1912. 4 pp., 7 figs., 1 table.

ECONOMY OF GAS ENGINES AND STEAM TURBINES, COMPARISON OF, Franklin M. Farwell. *Electrical World*, February 3, 1912. 2½ pp. 1 curve.

ENGINES FOR COLLIERY POWER STATIONS, GAS, J. Dunlop. *Engineering*, December 29, 1911. ⅔ p. *e*.

GASLUFTHEIZUNG IN DER WERKSTATT DELITZSCH, DIE, E. Krause. *Glaser Annalen*, January 15, 1912. 12 pp., 15 figs., 3 tables, 2 curves. *A*.

Gas-air heating plant using producer gas in railroad shops at Delitzsch.

GASTURBINE, DIE, R. Oldenburg. *The Engineer* (London), January 5, 1912. 2½ pp., 4 figs., 3 curves. *abfA*.

Extract and description of the 1000-h.p. Holzwarth gas turbine from the new book, Die Gasturbine, by Hans Holzwarth. New turbine greater than 30 per cent conversion of the primitive heat of combustion into mechanical energy at the turbine shaft.

GENERATOR FOR SMALL SIZED FUEL, THE KERPELY HIGH-PRESSURE GAS. *Stahl und Eisen*, December 28, 1911. 2½ pp., 3 figs., 1 table. *bf*.

See erratum in Stahl und Eisen, January 18, 1912, p. 118.

INTERNAL COMBUSTION ENGINE AT SEA, THE. *Engineering*, January 12, 1912. 1 p.

Comparison of existing types of internal-combustion engines and their adaptability to this class of service.

INTERNAL-COMBUSTION ENGINES, MARINE. *The Engineer* (London), January 5, 1912. 1 p. *bdB*.

Reviews progress made in 1911 by the internal-combustion engine for propulsion of ships.

KRAFTVERSORGUNG DES KLEINGEWERBES DURCH GAS UND ELECTRIZITÄT, Hoeltje. *Dinglers Polytechnisches Journal*, January 6 and 13, 1912. 8 pp., 7 tables, 7 curves. *A*.

The power supply by gas and electricity for small shops.

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[1] Opinions expressed are those of the reviewer not of the Society. Articles are classified as *a* comparative; *b* descriptive; *c* experimental; *d* historical; *e* mathematical; *f* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

MARINE GAS ENGINES: THEIR DESIGN AND APPLICATION, E. N. Percy. *International Marine Engineering*, January 1912. 3 pp.

Article continued from Vol. 16, p. 489.

MARINE OIL ENGINE, A THIRTY-DAY NON-STOP RUN OF A. *The Engineer* (London), January 26, 1912. 1 p. *bfB.*

Test of a model to prove the reliability of two 8-cylinder, 4-cycle, 2500-h.p. engines for S.S. Jutlandia.

PEAT GAS PRODUCER PLANT, A GERMAN, P. C. Percy. *Power*, January 9, 1912. 1⅔ pp., 3 figs. *b.*

Description of a plant consisting of a 300-h.p. engine and Heinze peat producer at the East German Exhibition at Posen.

PEAT GAS PRODUCER PLANT IN IRELAND, A SUCCESSFUL. *Power*, January 23, 1912. ⅔ p. *b.*

A Crossley installation of 400 h.p. replaces a Mond-Gas plant with a large saving in the annual fuel bill.

PETROL DRIVEN TRAMWAY CAR. *The Engineer* (London), January 19, 1912. 1 p., 2 figs. *bfC.*

Describes 55-h.p. petrol-driven cars to be used on 1½-mile line.

POWER PLANT FOR WOOLWICH FOOTWAY TUNNEL, TEMPORARY. *The Engineer* (London), January 12, 1912. 2 pp., 2 figs. *bfA.*

Three coupled gas engines, each 150 b.h.p. and three suction producers.

PRODUCER GAS TOW BOAT. *International Marine Engineering*, January 1912. 1 fig.

General description of small tug recently designed by W. J. Deed, Jr., of Boston. Producer capacity, 100 h.p.

PUMPMASCHINEN FÜR WASSERWERKE, NEUERE, R. Schweder. *Journal für Gas und Wasserversorgung*, January 6 and 13, 1912. 17 pp., 28 figs.

Latest pumping machinery for waterworks showing gas engine driven pumps.

SEEFISCHEREI-MOTOREN, F. Romberg. *Dinglers Polytechnisches Journal*, January 6 and 13, 1912. 11 pp., 41 figs., 11 curves.

Description, construction and design of gasolene motors for fishing boats.

SUCTION GAS PRODUCER, TESTS OF A, G. M. Garland and A. P. Kratz. *Bulletin University of Illinois*, October 16, 1911. 88 pp., 6 figs., 4 tables, 27 curves.

TURBINE, THE HOLZWARTH GAS. *Power*, February 6, 1912. 5 pp., 8 figs., 3 curves. *bc.*

A new type of gas turbine in which the fuel is intermittently burned in the combustion chamber and between times the chamber is cleaned by scavenging with a cooling medium.

GENERAL NOTES

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

The annual meeting of the American Society of Heating and Ventilating Engineers was held at the Engineering Societies Building in New York, January 23 to 25. In addition to the address of President R. P. Bolton, Mem. Am. Soc. M. E., on The Use and Abuse of Fuel, papers were presented as follows: Drying Apparatus, H. C. Russell and A Heat Exchange Diagram, N. W. Akimoff; Dust in Relation to Heating, Konrad Meier, Mem. Am. Soc. M.E.; Effect of Relative Humidity on Comfort and Health, J. I. Lyle, Mem. Am. Soc. M. E.; Chemical Notes on Ventilation, P. N. Evans; Ventilation Problems, D. D. Kimball; Steam Heating Large Department Stores, Davis S. Boyden; Hot Water Heating by Forced Circulation, Ira N. Evans; Auxiliaries for Pressure Systems of Hot Water Heating, J. J. Wilson; Steam Heating from the Receiver of the Compound Engine, Auguste Beaurrienne; Ventilating a Steam Laundry, A. M. Feldman, Mem. Am. Soc. M. E.; Heat Transmission with Indirect Radiation, Frank L. Busey; Tests of Vacuum Cleaning Tools and Exhausters, M. S. Cooley; Definition of the Unit of Heat, R. P. Bolton, Mem. Am. Soc. M. E.; Heating a Swimming Pool, Cesar Teran. Frank T. Chapman, Mem. Am. Soc. M. E., presented an informal paper on the ventilation, or rather the lack of ventilation of motion-picture theaters. Wm. Kent, Mem. Am. Soc. M. E., presented a special committee report on standards for pipe fittings and flanges.

Officers for the ensuing year were elected as follows: President, John R. Allen, Mem. Am. Soc. M. E.; Vice-Presidents, John F. Hale and E. F. Capron; Secretary, W. M. Macon, Jun. Mem. Am. Soc. M. E.; Treasurer, James A. Donnelly, Mem. Am. Soc. M. E. The following were elected to the Board of Governors, R. P. Bolton, Mem. Am. Soc. M. E.; James D. Hoffman, Mem. Am. Soc. M. E., F. R. Lewis, W. M. MacKay, D. D. Kimball.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS

The annual meeting of the Illinois Society of Engineers and Surveyors for 1912 was held at the University of Illinois, Urbana, Ill., on January 17, 18 and 19, and the program was of unusual excellence. The more important engineering topics discussed were stream pollution, sewage disposal, accuracy in surveying, road and pavement problems, and the bridge work of the Illinois Highway Commission. Two illustrated lectures of great interest were given, one by I. O. Baker on the Panama Canal, and one by H. L. Cooper on The Keokuk Water Power Plant. An afternoon was spent in inspecting the buildings and discussing the work of the College of Engineering.

AMERICAN INSTITUTE OF MINING ENGINEERS

The annual meeting of the American Institute of Mining Engineers was held February 19–21, 1912, at the Engineering Societies Building, New York. An informal social meeting was held on the evening of February 19, after which Charles Kirchhoff, Mem. Am. Soc. M. E., retiring president of the institute, gave an address on Institute Aims and Ideals. An informal smoker followed. Papers presented at the various professional sessions were in part as follows: Agglomeration of Fine Materials, W. S. Landis; Temperature Conversion-Tables, Leonard Waldo, Mem. Am. Soc. M. E.; Abrasion and Dust-Losses in Ore-Drying, C. F. Dietz, Mem. Am. Soc. M. E. and D. V. Keedy; Mine-Lamps, David B. Rushmore, Mem. Am. Soc. M. E.; Progress in Roll-Crushing, N. V. Hansell; A Concise Method of Showing Ore-Reserves, N. H. Emmons; Electrolytic Refining of Impure Copper, H. H. Emrich; Fuel Economy of Blast; The Smokeless Dry Coal Field of West Virginia, E. Ludlow.

IOWA ENGINEERING SOCIETY

The annual meeting of the Iowa Engineering Society was held February 21-23, 1912, at Davenport, Iowa. Among the papers presented were: Concrete roadways, J. H. Chubb, and Concrete Pavements with Bituminous Top Coat, N. H. Tunnicliff. The following reports were also made: Railroad Engineering, S. N. Williams; Sanitary Engineering, A. Marston; Minimum Highway Bridge Specifications, J. B. Marsh; Roads and Pavements, T. H. MacDonald; Legislation, Paul Beer. An inspection trip to the hydroelectric plant of the Mississippi River Power Company at Keokuk was enjoyed by the members in attendance.

KANSAS ENGINEERING SOCIETY

The annual meeting of the Kansas Engineering Society was held January 23 and 24, 1912, at Manhattan, Kan. The papers were as follows: How Roads Should be Classified and how the Different Classes Should be Constructed and Maintained, W. S. Gearhart, H. A. Rowland, C. C. Huntington, F. R. Hesser and E. E. Clark; Field Methods, Office Practice and Supervision and Inspection of Paving Work in Topeka, A. R. Young, E. G. Gibson and C. A. Foster; Work of the Engineering Department of the Public Utilities Commission, C. C. Witt; The Management of City Utilities and Their Valuation, C. S. Burns; The Velocity of the Flow of the Kansas River, V. R. Parkhurst; The Contamination of City Wells, S. C. Loper; The Use and Abuse of Sewage Disposal Plants, C. A. Smith.

PERSONALS

John F. Allison has resigned from Clemson Agricultural College, Clemson College, S. C., as instructor in forge and foundry, to accept a position as instructor in mechanical engineering and shopwork at Maryland Agricultural College, College Park, Md.

Fred. W. Ballard has been appointed engineer of construction of the new electric lighting plant of the City of Cleveland, O. Mr. Ballard has been serving as the manager of the engineering and construction department of the Sherwin-Williams Co., Cleveland, O.

Frederick W. Cox has assumed the duties of general salesman of Shewan Tomes & Co., Hongkong, China.

Charles H. Craig, Jr., formerly with Chas. T. Main of Boston, Mass., has become associated with Edward H. McClintock, under the firm name of McClintock & Craig, engineers and architects, with offices in Springfield, Mass.

W. G. Diman has accepted a position with the Amoskeag Manufacturing Co., Manchester, N. H., in the capacity of supervising engineer.

L. L. Griffiths has resigned his position of general superintendent of the Texas Portland Cement Co., and opened an office in Dallas, Tex., as president of the L. L. Griffiths Engineering Co., consulting civil, mechanical and electrical engineers. Mr. Griffiths is retained by the Texas Portland Cement Co. as consulting engineer.

F. A. Haughton has accepted a position with the Remington Arms and Ammunition Co., Ilion, N. Y., in the capacity of works manager. He was recently general superintendent of the Taylor Iron and Steel Co., High Bridge, N. J.

George J. Henry, Jr. has resigned as chief engineer and sales manager of the Pelton Water Wheel Co., San Francisco, Cal., to open an engineering office in the same city.

O. Z. Howard has accepted a position with the Griscom-Spencer Co., New York. He was formerly associated with the U. S. Naval Engineering Experiment Station, Annapolis, Md.

Harry M. Latham has assumed the duties of manager of the steam and electrical departments of B. F. Sturtevant Co., Hyde Park, Mass. He was until recently associated with the American Steel and Wire Co., Worcester, Mass.

Leo Loeb, formerly identified with the Cambria Steel Co., Johnstown, Pa., in the capacity of assistant steam engineer, has entered the service of the Naval Experiment Station, Annapolis, Md.

V. M. Palmer has assumed the duties of standardizing engineer with the

U. S. Motor Co., New York. He was formerly factory manager and chief engineer of the B. F. Board Motor Truck Co., Alexandria, Va.

H. W. Peck has been appointed vice-president and general manager of the Schenectady Illuminating Co., Schenectady, N. Y. Mr. Peck was until recently associated with the Rochester Railway and Light Co., Rochester, N. Y., as assistant to general manager.

George B. Pickop has assumed the duties of general superintendent of the Universal Machine Screw Co., Hartford, Conn. He was formerly master mechanic with P. & F. Corbin, New Britain, Conn.

E. Posselt has opened an office as consulting mechanical and industrial engineer, in Denver, Colo. He was connected with the Colorado Portland Cement Co. as engineer in charge of construction, and since January 1912, has been retained as consulting engineer for the Cement Securities Co., Denver, Colo.

E. P. Roberts has been appointed smoke inspector of Cleveland, O.

P. F. Smith, Jr. has been appointed superintendent of motive power of the Pennsylvania Lines, Toledo, O. He was formerly master mechanic of the Pennsylvania Railroad Shops, Columbus, O.

Robert I. Todd, who has acted as general manager of the Indianapolis Traction and Terminal Co., was elected president of the company, to succeed the late Hugh J. McGowan. Mr. Todd likewise succeeds Mr. McGowan as president of the Terre Haute, Indianapolis and Eastern Traction Co., one of the longest lines in the State.

C. R. Whittier has become associated with the General Chemical Co., New York. He was formerly connected with the Standard Plunger Elevator Co., New York.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for the Bulletin must be in hand before the 12th of the month. The list of men available is made up of members of the Society, and these are on file in the Society office, together with names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

0144 Young man for office to take charge of sales department of triplex pump business. Location Middle West. Apply through Am. Soc. M. E.

0145 Designer on automobile work, one preferred who has had experience in gear case design, knowledge of high speed transmission and worm gearing. Good mathematician with knowledge of strength of materials. New York.

0146 Young technical graduate, good draftsman, capable of taking hold of mechanical heat and power tests for purpose of securing data for the modification or improvement of existing apparatus. Location Colorado.

0147 Man to take charge of gear cutting department. Position will pay from $1800 to $3000 to right party, depending on the ability of the man who can take the department and show results of uniform quality and quantity; must be thoroughly up in theory and practice on bevel and spur gears and have a record as a producer. Location Middle West.

0148 Large stationary gas engine manufacturers in England, desire man thoroughly familiar with systematization of large enterprises to take up work of reorganization of their plant. Apply through Am. Soc. M. E.

0149 Prominent maker of air compressors is in need of three experienced and efficient salesmen. State details of previous experience, references and compensation expected. Answer in handwriting. Address care of Am. Soc. M. E.

0150 Young man with technical knowledge and shop experience, as assistant foreman of concern manufacturing pressure reducing and regulating valves and other specialties. Position offers good opportunities for advancement to a young man with ambition.

MEN AVAILABLE

369 Manager, technically trained with 15 years' experience in shop designing, engineering sales and management, desires to change for position in business, sales or executive end of manufacturing concern. Capable of manufacturing executive work or of managing manufacturers agency proposition.

370 Mechanical engineer, 14 years' experience in engineering and buying, desires to represent reliable eastern firm in San Francisco. Either sales or engineering work.

371 Master mechanic or superintendent of power, desires position. Can produce results. Familiar with large steam or gas power plants; would accept position with mechanical engineer to make tests on power propositions. Thirty-nine years of age, married. Can furnish best of references.

372 Technical graduate of seven years' standing with both technical and business experience, desires to purchase interest in paying manufacturing business, which desires to increase capital and where technical knowledge will be useful.

373 Member, mechanical engineer, power plant and mill engineering, heating, ventilating, extensive experience in design, office work and field work. Best of references. Desires executive position.

374 Mechanical and construction engineer, technical education, 12 years' broad practical experience, desires responsible position in manufacturing or engineering lines. Forceful and energetic, executive and business ability, systematic and direct; understands values and economics of production, originality and inventive ability. Capable of responsible charge of manufacturing department.

375 Technical graduate, experienced in laying out and installing industrial plants and electric installations; married; age 32. Desires position as manager or superintendent of small growing factory; practical experience in machine shop and drafting room, devising and installing complete cost, shop and production systems, factory executive in responsible charge.

376 Junior; technical graduate, age 28, married, eight years' experience; designing, estimating costs, inspecting, with company manufacturing railroad cars and contractor's equipment; assistant engineer on power and industrial plant design; heating and ventilating; selling; at present employed. Desires position with engineer, contractor or manufacturer as assistant, branch manager or sales engineer.

377 Associate; technical education; 12 years' experience, familiar with latest manufacturing methods; desires position as master mechanic or efficiency engineer, requiring extensive knowledge of the shop.

378 Stevens graduate, married; varied experience with representative concerns in lines of manufacture and mechanical engineering, at present connected with large manufacturing concern, working in lines of reorganization and improvements of methods including planning, standardization of operations, classification, rearrangement, cataloging, symbolizing stock, ready to take up work in similar lines. Leaving present employer with full consent.

379 Member, technical graduate, long experience as testing engineer, chief engineer, superintendent and consulting mechanical engineer with extensive experience in steam and electric power companies, textile, rubber and other industrial corporations. Special experience in reducing operating costs in indus-

trial power plants, management of mechanical and operating departments. Desires position as executive mechanical engineer or superintendent with large industrial or power company.

380 Young engineer, with literary and editorial experience, imagination, executive ability and knowledge of men desires position in active engineering work. Previous experience in design, systematizing, assistant engineer.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

Adressbuch der deutschen Maschinenfabriken. Jahrgang 5, 1911-1912. *Leipzig, 1911.*

American Institute of Architects. Quar. Bull., vol. 1. *Washington, 1900.*

American Society of Municipal Improvements. Proc. of Annual Convention, 2d, 4th-7th. v.p—1895, 1897-1900.

Calculation of Columns. A Practical Application of the Theory, Theodor Nielsen. *London-New York, 1911.*

Cambria Steel. A Handbook of Information Relating to Structural Steel, Manufactured by the Cambria Steel Company, 1909, G. E. Thackray. *Johnstown, 1909.* Gift of the author.

Cane Sugar, Noël Deerr. *Altrincham, Manchester, 1911.*

Chemical Manufacturers' Directory of England, Wales and Scotland, with some of the Firms in Ireland. 1911. ed. 43. *London, 1911.*

Chemins de Fer Funiculaires Transports Aériens, A. Levy-Lambert. ed. 2. *Paris.*

Ciencias Pedagógicas y Filosofia. Vol. 2. Congreso Cientifico (1° Pan Americano), vol. 13. *Santiago de Chile, 1911.* Gift of the Congreso Cientifico.

Complément de la Première Edition fe la Résistance de L'Air et L'Aviation. Expériences effectuées au Laboratoire du Champ de Mars, G. Eiffel. *Paris, 1911.* Gift of the author.

Concrete Engineering, vols. 1-2. *Cleveland, 1907.*

Design and Construction of Ships, J. H. Biles, vols. 1-2. *London, 1908, 1911.*

Detroit Board of Water Commissioners. Annual Report, 59th. *Detroit, 1911.* Gift of the board.

Dudley, Charles B. Memorial volume, 1842-1909. *Philadelphia.* Gift of American Society for Testing Materials.

Die Eisenbetonpraxis, E. Nicolas. *Wien, 1911.*

Emploi du Béton Armé, P. Planat. *Paris.*

Entropy-Temperature Analysis of Steam-Engine Efficiencies; with a Blank Diagram arranged for Easy Application to any Concrete Case, S. A. Reeve. *New York, 1897.* Gift of Progressive Age Publishing Company.

Experiments in Strength of Materials and Cement Laboratory, E. B. Smith. *Philadelphia, 1911.* Gift of the author.

Fibres Used in Textile and Allied Industries, C. A. Mitchell and R. M. Prideaux. *London, 1910.*

Le Froid Industriel et ses Applications.

Gazogènes et Moteurs à Gaz Pauvre à la Portée de Tous, René Champly. *Paris, 1911.*

Hardening and Tempering Steel, B. E. Jones. *London-New York, 1911.*

Heat Treatment of Tool Steel, Harry Brearley. *New York, Longmans, Green & Co., 1911.*

Hydrodynamics, Horace Lamb. ed. 3. *Cambridge, 1906.*

International Navigation Congress, 11th Report of Proceedings, 1908. *Brussels, 1908.*

———Inland Navigation. Reports, Communications. 2 vols. *Brussels, 1908.*

———Ocean Navigation. Reports, Communications. 2 vols. *Brussels, 1908.*

Kansas City Board of Commissioners. Report on Water Works Extension, L. Riley and W. Kiersted, 1912. *Kansas City, 1912.* Gift of Wynkoop Kiersted.

Kinematics of Machines, R. J. Durley. ed. 2. *New York, 1911.*

Leading American Men of Science, D. S. Jordan. *New York, 1910.*

League of Improvement Societies in Rhode Island. Year Book, 1911-1912. Gift of Brown & Sharpe Mfg. Co.

Manufacture of Sulphate of Ammonia, G. T. Calvert. *London, 1911.*

Le Matériel des Chemins de Fer, J. B. Flamme. *Paris, 1911.*

Mechanism of Weaving, T. W. Fox. *London, 1911.*

Modern Methods of Sewage Purification, G. B. Kershaw. *London, 1911.*

Monthly Official Railway List, January 1912. Gift of Railway List Company.

Municipal Journal and Engineer, vols. 14-19. *New York, 1903-1905.*

Panama Canal. Notes and views taken by members of the American Society of Civil Engineers during their visit, March 1911. *Boston, 1911.* Gift of G. A. Kimball.

Physico-Chemical Tables for the Use of Analysts, Physicists, Chemical Manufacturers and Scientific Chemists, J. C. Evans. Vols. 1-2. *London, 1902, 1911.*

Protection of New York's Water Supply from Pollution During Construction Work, A. J. Provost, Jr. Reprinted from Journal of New England Water Works Association, vol. 25, no. 3. Gift of Messrs. Lederle and Provost.

Rhode Island Traction Improvement and Development. Report of the Joint Committee on Railroad Franchises, June 1911, B. J. Arnold. *Providence, 1911.* Gift of the author.

Sewerage Systems, Their Design and Construction, H. S. Watson, with Legal Notes by E. B. Herbert. *London, 1911.*

Short Course in Graphic Statics for Students of Mechanical Engineering, W. L. Cathcart and J. I. Chaffee. *New York, Van Nostrand Co., 1911.*

This is an abridgement of the authors' larger book, Elements of Graphic Statics. Its purpose is to provide students of mechanical engineering with a brief course of graphic statics which will serve when the time to be devoted to the subject is short. The treatment has been restricted mainly to the properties and general uses of the force and equilibrium polygons. Some attention has been given to the design of trusses.

STEAM ENGINE AND TURBINE. A TEXT-BOOK FOR ENGINEERING COLLEGES. R. C. Heck. *New York, Van Nostrand Co., 1911.*

Partly adapted from the writer's Steam Engine and Other Steam Motors, but largely rewritten. The furnace and boiler and their accessories are not considered, except to make frequent reference to their functions. The book has an extremely adequate index.

SULLA TEORIA ANALITICA DELLE ELICHE E SU ALCUNI METODI SPERIMENTALI, G. A. Crocco. (Rendiconti degli Studi ed Esperienze, vol. 1, no. 1). *Roma, 1911.*

TECHNOLOGY OF BREAD MAKING, William Jago and W. C. Jago. *London, 1911.*

TEXT-BOOK ON GAS, OIL AND AIR ENGINES, Bryan Donkin. ed. 5. *London, 1911.*

THOMAS' REGISTER AND FIRST HANDS IN ALL LINES. ed. 5, 1912. *New York, 1912.*

TRAITÉ PRATIQUE DE LA POSE ET L'ENTRETIEN DES CANALISATIONS DE GAZ, F. Barbe. *Paris, 1910.*

TRANSPORTATION BY RAIL; An Analysis of the Maintenance and Operation of Railroads, T. M. R. Talcott. *Richmond, 1904.*

WATER WORKS EFFICIENCY 1. WATER WASTES SURVEY. Bull. No. 11, Milwaukee Bureau of Economy and Efficiency. *Milwaukee, 1911.*

WELTADRESSBUCH DER CHEMISCHEN INDUSTRIE, 1911. *Berlin, 1911.*

WHITAKER'S ALMANAC, 1912. *London, 1912.*

GIFT OF JOHN CALDER

AMERICAN LABOR LEGISLATION REVIEW. Vol. 1, no. 4, December, 1911.

CITY CLUB BULLETIN. Vol. 5, no. 6, January 24, 1912.

LABOR LAW IMPROVEMENT AND ENFORCEMENT: The Manufacturer's Attitude, John Calder. Reprinted from publications of the Academy of Political Science, vol. 2, no. 2. *New York, 1911.*

NATIONAL CIVIC FEDERATION. Proc. Department on Compensation for Industrial Accidents and Their Prevention, December 8, 1911.

SURVEY. Vol. 27, no. 16, January 20, 1912.

EXCHANGES

AMERICAN SOCIETY OF CIVIL ENGINEERS. Trans., vol. 69, 1910. *New York, 1910.*

INSTITUTION OF AUTOMOBILE ENGINEERS. Proc., vol. 5. *Westminster, 1911*

MASTER CAR BUILDERS' ASSOCIATION. Report of the Proceedings, vol. 45. *Chicago, 1911.*

SMITHSONIAN INSTITUTION. Annual Report, 1910. *Washington, 1911.*

UNITED ENGINEERING SOCIETY

GESCHAFTS-BERICHT DER DEUTSCHEN BUCHDRUCKER BERUFS-GENOSSENSCHAFT ÜBER DAS RECHNUNGSJAHR, 1910. *Frankfurt-am-Main.*

VIRGINIA STATE CORPORATION COMMISSION. Annual Report, 8th, 1910. *Richmond, 1911.*

———Appendix to Annual Report, 8th, 1910. *Richmond, 1911.* Gift of T. C. Martin.

IOWA RAILROAD COMMISSIONERS. Annual Report, 33d, 1910. *Des Moines, 1910.* Gift of American Electric Railway Association.

WISCONSIN RAILROAD COMMISSION. Opinions and Decisions, vol. 4. *Madison, 1910.* Gift of American Electric Railway Association.

TRADE CATALOGUES

ASSOCIATIÓN OF AMERICAN PORTLAND CEMENT MANUFACTURERS, *Philadelphia, Pa.* Factories and warehouses built of reinforced concrete, 223 pp.

BEST MANUFACTURING CO., *Pittsburgh, Pa.* Catalogue and handbook of piping material, for steam, air, hydraulic work and high and low pressure, 396 pp.

HENDEE MFG. CO., *Springfield, Mass.* Indian motorcycles for 1912, 24 pp.

HESS-BRIGHT MFG. CO., *Philadelphia, Pa.* Data sheet on worm mounting; worm and worm-gear mounting; bearing mountings, without shoulders on shafts; change gear case typical mounting, 9 sheets.

CHAS. E. MILLER, *New York.* Motorcars; motorboats; motorcycles; motorplanes and accessories, 114 pp.

TOLEDO ELECTRIC WELDER CO., *Cincinnati, O.* Bull. No. 11, Butt welding machines, 35 pp.

VEEDER MFG. CO., *Hartford, Conn.* Veeder products including mileage recorders, tachometers, telephone counters, etc., 84 pp.

UNITED ENGINEERING SOCIETY

SIMPLEX CONSTRUCTION CO., *New York.* Simplex system of concrete piling, 96 pp.

CHANGES IN MEMBERSHIP

CHANGES IN ADDRESS

ALLISON, John Franklin (Junior, 1910), Instr. Mech. Engrg. and Shop work, Md. Agri. College, College Park, Md., and 33 Q St., N. E., Washington, D. C.

BARRON, Claude M. (Junior, 1910), Cons. Engr., R. W. Cameron & Co., 23 S. William St., New York, N. Y., and 2009 Forest Ave., St. Louis, Mo.

BAYLIS, Arthur Raymond (1905; 1906), Ewing, Bacon & Henry, 30 Church St. New York, and *for mail*, 1815 Ave. K, Flatbush, Brooklyn, N. Y.

BIBBINS, James Rowland (1904; 1909), Engr. with Bion J. Arnold, 105 S. La Salle St., Chicago, Ill., and *for mail*, 1310 Hewes Bldg., San Francisco, Cal.

BILLINGS, A. W. K. (1909), Barcelona Traction, Light & Power Co., Apartado 491, Barcelona, Spain.

BLOOD, John Balch (1895; 1903), Cons. Engr., 10 P. O. Sq., Boston, and *for mail*, 232 High St., Newburyport, Mass.

BROWN, John Quincy (1906), Ch. Engr. Mech. and Elec. Dept., Oakland Traction Co., and San Francisco, Oakland & San Jose Ry., Oakland, Cal.

BUFFUM, F. D. (1902; Associate, 1904), Ellsworth, Washington Co., Pa.

CHAMBERLAIN, Harry M. (1907), Macker-Tyler Co., 31 Central St., Worcester, and *for mail*, 17 Wrentham St., Dorchester Centre, Mass.

CHILDS, Eugene (1899), Rep., Gath Mch. Tool Co., 61 Terrace, Buffalo, N. Y., and *for mail*, 410 E. 6th St., Erie, Pa.

COX, Frederick W. (1908), Genl. Salesman, Shewan Tomes & Co., Hongkong, China.

CRAIG, Charles H., Jr. (1908), Member of Firm, McClintock & Craig, 33 Lyman St., Springfield, Mass.

DAM, William Valdemar (1906), Genl. Mgr., Thompson & Co., and *for mail*, "Kalimna," Hall St., Castlemaine, Victoria, Australia.

DAVIS, William J., Jr. (1910), Pacific Coast Engr., Genl. Elec. Co., 720 Rialto Bldg., San Francisco, Cal., also Ch. Engr., Mexican No. Power Co., Montreal, Canada.

DIMAN, Walter G. (1909), Supv. Engr., Amoskeag Mfg. Co., Manchester, N. H.

DU BARRY, Ed. G. (Junior, 1910), Minneapolis Steel & Mchy. Co., and *for mail*, 2604 Aldrich Ave., S., Minneapolis, Minn.

DUNLAP, George W. (1911), Pub. Service Com., 1828 Tribune Bldg., New York, N. Y.

FLINN, Charles Forrest (Associate, 1905), Supt., L. E. White Lumber Co., Balboa Bldg., San Francisco, and Elk, Mendocino Co., Cal.

FREDERICK, Floyd W. (1907), Prof. Mech. Engrg., Howard Univ., and *for mail*, 607 Taylor St., N. W., Washington, D. C.

GERRISH, William H. (1901), Ch. Smoke Inspr., Bd. of Gas and Elec. Light Commrs., Commonwealth of Mass., 603 Ford Bldg., 15 Ashburton Pl., Boston, and *for mail*, 173 Main St., Malden, Mass.

HAUGHTON, Frank A. (1903), Wks. Mgr., Remington Arms & Ammunition Co., Ilion, N. Y.

HOUSKEEPER, Wm. G. (Junior, 1906), Engr., Westinghouse Lamp Co., Bloomfield, N. J., and *for mail*, 3508 Baring St., Philadelphia, Pa.

HOWARD, O. Zell (1908), The Griscom Spencer Co., 90 West St., New York, N. Y.

JONES, Benjamin N. (1904), Mgr. of Mfg., Otis Elevator Co., New York, N. Y., and *for mail*, 296 Essex Ave., Orange, N. J.

KEITH, Thomas M. (1905; 1910), 241 Clifton Pl., Brooklyn, N. Y.

LEAMAN, Charles Henry (Junior, 1910), 1242 Perkiomen Ave., Reading, Pa.

LEE, Ralph A. (Junior, 1909), Engr. Mfg. Dept., Barrett Mfg. Co., 17 Battery Pl., New York, and *for mail*, 578 75th St., Brooklyn, N. Y.

LEIGHTON, Edward I. (1892), St. Augustine, Fla., and 1183 East Blvd., Cleveland, O.

LEITCH, Meredith (1898), Mech. Engr., De Laval Separator Co., Poughkeepsie, N. Y.

LOEB, Leo (Junior, 1911), Mech. Engr., Naval Exper. Sta., Annapolis, Md.

LOWE, Henry Leland (Junior, 1903), Genl. Motors Co., and *for mail*, 544 Field Ave., Detroit, Mich.

McMULLIN, Frank V. (1903), Treas., Pa. Forge Co., Philadelphia, Pa.

MAHL, F. W., (1892; 1910), Union Pacific System So. Pacific Co., 165 Broadway, New York, and *for mail*, 20 Primrose Ave., Mt. Vernon, N. Y.

MERRILL, Albert S. (Junior, 1903), 125 N. 3d St., Easton, Pa.

MERRILL, Joseph J. (1911), Ch. Engr., Corn Products Refining Co., 29 E. Madison St., and 229 S. Central Park Ave., Chicago, Ill.

MOXHAM, Egbert (Junior, 1906), Asst. Mgr. Development Dept., E. I. du Pont de Nemours Co., and *for mail*, 1101 Rodney St., Wilmington, Del.

NETTLETON, William Alpheus (1905), 1625 Prairie Ave., Chicago, Ill.

NORRIS, William H., Jr. (Junior, 1909), Engr., 3622 Chestnut St., Philadelphia, Pa.

OLIVER, E. C. (Junior, 1902), Factory Mgr., Renfro Speedometer Co., 302 Palmer Bldg., 70 Washington Blvd., Detroit, Mich.

PARISH, Wm. H. (Junior, 1905), Commer. Engr., Westmoreland Coal Co., 224 S. 3d St., Philadelphia, and 128 Tulpohocken St., Germantown, Philadelphia, Pa.

PEARSON, Walter Ambrose (1907), 135 Front St., New York, N. Y.

PECK, Henry W. (Associate, 1908), V. P. and Genl. Mgr., Schenectady Ill. Co., Schenectady, N. Y.

PICKOP, George B. (1908), Genl. Supt., Universal Mch. Screw Co., 806 Windsor St., Hartford, Conn.

POSSELT, Ejnar (Junior, 1907), Cons. Mech. and Industrial Engr., 511 Ideal Bldg., Denver, Colo.

PRATT, Charles Richardson (1896), Cons. Engr., 39 Gates Ave., Montclair, N. J.

PRICE, Norman I. (Junior, 1902), Price & Martyn, 68½ Pitt St., Sydney, N. S. W., Australia.

QUICK, Ray Lewis (Junior, 1911), Pratt & Whitney Co., 111 Broadway, New York, and *for mail*, 166 Remsen St., Brooklyn, N. Y.

QUIMBY, William E. (1889; 1905), Pres., William E. Quimby, Inc., 548 W. 23d St., New York, N. Y., and Llewellyn Park, Orange, N. J.

ROGERS, John I. (Junior, 1910), Cons. Engr., 929 Chestnut St., Philadelphia, and Wyncote, Pa.

ROWLEY, Harry Wm. (1896), 2138 California St., Washington, D. C.

ROWLEY, Ridgway Lloyd (Junior, 1910), Inspc. Engr., Bd. of Fire Underwriters of the Pacific, 914 Merchants Exch., San Francisco, and 398 60th St., Oakland, Cal.

ROYSE, Daniel (1891; 1904), Asst. to Dir. of Purchases, Union Pacific R. R., 165 Broadway, New York, N. Y.

ST. CLAIR, James Thorpe (Junior, 1901), Pres., Wesley Mfg. Co., 314 S. 8th St., St. Louis, Mo.

SAR VANT, Wilbur Nason (Junior, 1907), 16 Verona Pl., Brooklyn, N. Y.

SCOTT, Walter G. (Junior, 1909), Fenton, Mich.

STRAUSS, Julian B. (1910), care of Martin Strauss, Schumanstr. 29, Frankfort, Germany.

THOMPSON, Albert W. (1900;1907), Supt., Lowell Mch. Shop, and Fairmount St., Lowell, Mass.

VALENTINE, Warren P. (Junior, 1904), Engrg. Dept. and Charge of Mech. Drawing Dept., Trades Apprentice Sch. of Westinghouse Elec. & Mfg. Co., East Pittsburgh, and *for mail*, 204 West St., Wilkinsburg, Pa.

WALLIS, James T. (1901), Genl. Supt. M. P., Pa. R. R., Lines East of Pittsburgh, Altoona, Pa.

WELLS, J. Barnard (Junior, 1909), 44 Oakvale Ave., Berkeley, Cal.

WHEELER, Frank R. (1909), Member of Firm, Guernsey & Wheeler, 436 Rialto Bldg., San Francisco, and 700 Central Bldg., Los Angeles, Cal.

WHITTIER, Chas. Robert (1909), Genl. Chem. Co., 25 Broad St., and *for mail*, 204 W. 111th St., New York, N. Y.

WILE, Julius I. (1904; 1908), Chalmers & Williams, Chicago Heights, Ill.

WILLIAMS, Alan Gillespie (Junior, 1909), Eng. House Foreman, Vandalia R. R., and *for mail*, 447 N. 7th St., Terre Haute, Ind.

WILLIAMS, Charles Henry (1901; 1904), Genl. Mgr., The No. Colo. Power Co., 1008 Gas and Elec. Bldg., Denver, Colo.

WISEWELL, Francis H., Jr. (Junior, 1905), V. P., Mohawk Valley Htg. Co., 22 Broad St., and *for mail*, The Olbiston, Genesee St., Utica, N. Y.

WUERFEL, Geo. D. (1908), Member of Firm, Wuerfel & Miggett, 1125 Ohio Bldg., and *for mail*, 823 Erie St., Toledo, O.

WYATT, Edgar William (1910), The M. Werk Co., Poplar St., Cincinnati, O.

YOUNG, Gilbert A. (1906), Acting Prof. Mech. Engrg., Purdue Univ., and *for mail*, 725 Highland Ave., Lafayette, Ind.

NEW MEMBERS

BRAUN, Horace Herbert (Junior, 1911), Mech. Engr., U. S. Smelting, Refining & Min. Co., Las Cajas, Pachuca, Hidalgo, Mex.

CLARK, Charles Ethan (1911), Mfg. Saw Mill Mchy., Steam and Gas Engs., 406 N. Main St., Wellsville, N. Y.

DU PRIEST, John Randolph (1911), 921 E. State St., Ithaca, N. Y.

ELROD, H. E. (1911), Genl. Mgr., Union Iron Wks., and *for mail*, 1909 Crawford St., Houston, Tex.

HOPKINSON, Allen Haigh (1911), Gov. Dir., J. Hopkinson & Co., Ltd., Britannia Wks., Huddersfield, England.

JONES, John Lucien (Junior, 1911), Asst. Prof. Mech. Engrg., Okla. Agri. and Mech. College, Stillwater, Okla.

LINDQUIST, Eric Adolf (Junior, 1911), Middletown, Conn.

McNEILL, Joseph Hensley (1911), Ch. Inspr., Boiler Inspc. Dept., and Chairman Bd. of Boiler Rules, Commonwealth of Mass., State House, Boston, Mass.

MAUGER, David Napier (Junior, 1911), Draftsman and Estimator Engrg. Dept., Babcock & Wilcox Co., Bayonne, and *for mail*, 705 W. 7th St., Plainfield, N. J.

MOONEY, Franklin Proctor (Junior, 1911), Ch. Electrician, The Arrowhead Reservoir & Power Co., San Bernardino, Cal.

PAWLETT, Louis M. (Junior, 1911), Exec. Engr., Locomobile Co. of Am., and *for mail*, 231 Fairfield Ave., Bridgeport, Conn.

POTTER, Philip Arthur (1911), Hyd. Cons. Engr. with Nicholas S. Hill, Jr., 100 William St., and *for mail*, 315 W. 97th St., New York, N. Y.

REARDON, Patrick H. (Associate, 1911), Pres. and Genl. Mgr., The Compressed Air Mchy. Co., 39-51 Stevenson St., San Francisco, Cal.

ROCKWOOD, George O. (1911), Pres., The Rockwood Mfg. Co., P. O. Box 636, Indianapolis, Ind.

ROTE, John G. (Junior, 1911), Gillette Safety Razor Co., and *for mail*, 84 Prescott St., Cambridge, Mass.

STOUGHTON, Bradley (1911), Cons. Engr., 165 Broadway, New York, N. Y.

THOMSON, John Edgar (Junior, 1911), Engr. and Designer, John Thomson Press Co., 253 Broadway, New York, N. Y.

WATKINS, Frank Elias (1911), Asst. Mgr., Power & Min. Mchy. Co., Internatl. Gas Eng. Co., Cudahy, and *for mail*, 545 Superior St., Milwaukee, Wis.

WOODMANSEE, Fay (1911), Cons. Engr., Woodmansee, Davidson & Sessions, 1048 First Natl. Bank Bldg., Chicago, Ill.

PROMOTIONS

DORNER, Frederick Harry (1907; 1911), Mech. Engr., Bayley Mfg. Co., and *for mail*, 716 Prospect Ave., Milwaukee, Wis.

DEATHS

BUCK, W. F., January 31, 1912.

SANCTON, Edward K., December 26, 1911.

STILLMAN, Francis H., February 18, 1912.

COMING MEETINGS

March-April

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading, and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

AMERICAN ASSOCIATION OF RAILROAD SUPERINTENDENTS
March 17, annual meeting, Chicago, Ill. Secy., O. G. Fetter, Carew Bldg., Cincinnati, Ohio.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION
March 12-15, annual convention, New Orleans, La. Secy., J. D. Farasey, E. 37th St. and Erie R. R., Cleveland, O.

AMERICAN RAILWAY ENGINEERING ASSOCIATION
March 19-21, annual convention, Chicago, Ill. Secy., E. H. Fritch, Monadnock Blk.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
April 8, monthly meeting, 29 W. 39th St., New York. Secy., F. L. Hutchinson.

AMERICAN SOCIETY OF CIVIL ENGINEERS
March 6, 20, bi-monthly meetings, 220 W. 57th St., New York. Secy., C. W. Hunt.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Monthly Meetings: New York, March 12; Boston, March 15; Philadelphia, March 7. Secy., Calvin W. Rice, 29 W. 39th St.

CANADIAN FREIGHT ASSOCIATION
April 11, annual meeting, Montreal, Que. Secy., T. Marshall, Toronto, Ont.

CANADIAN MINING INSTITUTE
March 6, annual meeting, Ottawa, Can. Secy., H. Mortimer-Lamb, Windsor Hotel, Montreal.

MISSOURI HIGHWAY ENGINEERS' ASSOCIATION
March 14-21, annual convention, Kansas City, Mo.

NATIONAL ASSOCIATION OF CEMENT USERS
March 11-16, annual convention, Kansas City, Mo. Secy., Edward E. Krauss, Harrison Building, Philadelphia, Pa.

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS
April 24-25, annual meeting, Charitable Mechanics Bldg., Boston, Mass. Secy., C. J. H. Woodbury, 45 Milk St.

NATIONAL BRICK MANUFACTURERS ASSOCIATION

March 6-9, annual convention, Chicago, Ill. Secy., T. A. Randall, Indianapolis, Ind.

NATIONAL CIVIC FEDERATION

March 5-7, annual meeting, Washington, D. C. Secy., D. L. Cease, 1 Madison Ave., New York.

NATIONAL METAL TRADES ASSOCIATION

April 11, annual convention, Hotel Astor, New York. Secy., H. D. Sayre, New England Bldg., Cleveland, Ohio.

NEW ENGLAND RAILROAD CLUB

March 12, annual meeting, New American House, Hanover St., Boston, Mass. Secy., Geo. H. Frazier, 10 Oliver St.

NEW ENGLAND SECTION OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION

March 14-15, annual meeting, Hotel Kimball, Springfield, Mass.

NEW ENGLAND STREET RAILWAY CLUB

March 19, annual banquet, Hotel Somerset, Boston, Mass. Temp. Secy., H. A. Faulkner, 12 Pearl St.

RAILWAY SIGNAL ASSOCIATION

March 18, semi-annual meeting, New York. Secy., C. C. Rosenberg, Bethlehem, Pa.

SOUTHERN GAS ASSOCIATION

April 17-19, annual meeting, Jacksonville, Fla. Secy., E. D. Brewer, Atlanta Gas Light Co., Atlanta, Ga.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
March			
5	Institute of Operating Engineers	H. E. Collins	8.00 p.m.
8	American Institute of Electrical Engineers	F. L. Hutchinson	8.15 p.m.
12	American Society of Mechanical Engineers	C. W. Rice	8.15 p.m.
14	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
15	New York Railroad Club	H. D. Vought	8.15 p.m.
27	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
28	Institute of Operating Engineers	H. E. Collins	8.00 p.m.
April			
2	Institute of Operating Engineers	H. E. Collins	8.00 p.m.
5	American Institute of Electrical Engineers	F. L. Hutchinson	8.15 p.m.
9	American Society of Mechanical Engineers	C. W. Rice	8.15 p.m.
11	Illuminating Engineering Society	P. S. Millar	8.15 p.m.
16	New York Telephone Society	T. H. Lawrence	8.15 p.m.
19	New York Railroad Club	H. D. Vought	8.15 p.m.
24	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
25	Institute of Operating Engineers	H. E. Collins	8.00 p.m.

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Rensselaer Poly. Inst.	Dec. 9, 1910	A. M. Greene, Jr.	W. D. Small	A. E. Moore
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Ohio State University	Jan.10, 1911	E. A. Hitchcock	J. P. Stewart	H. F. Belt
Washington University	Mar.10,1911	E. L. Ohle	E. Dougherty	F. E. Glasgow
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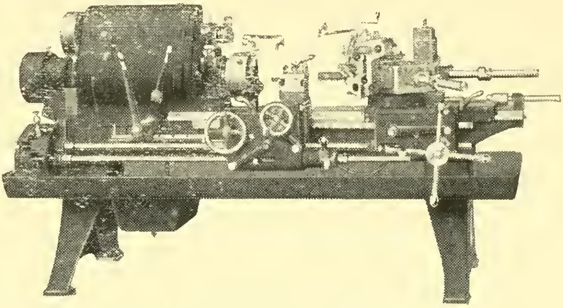

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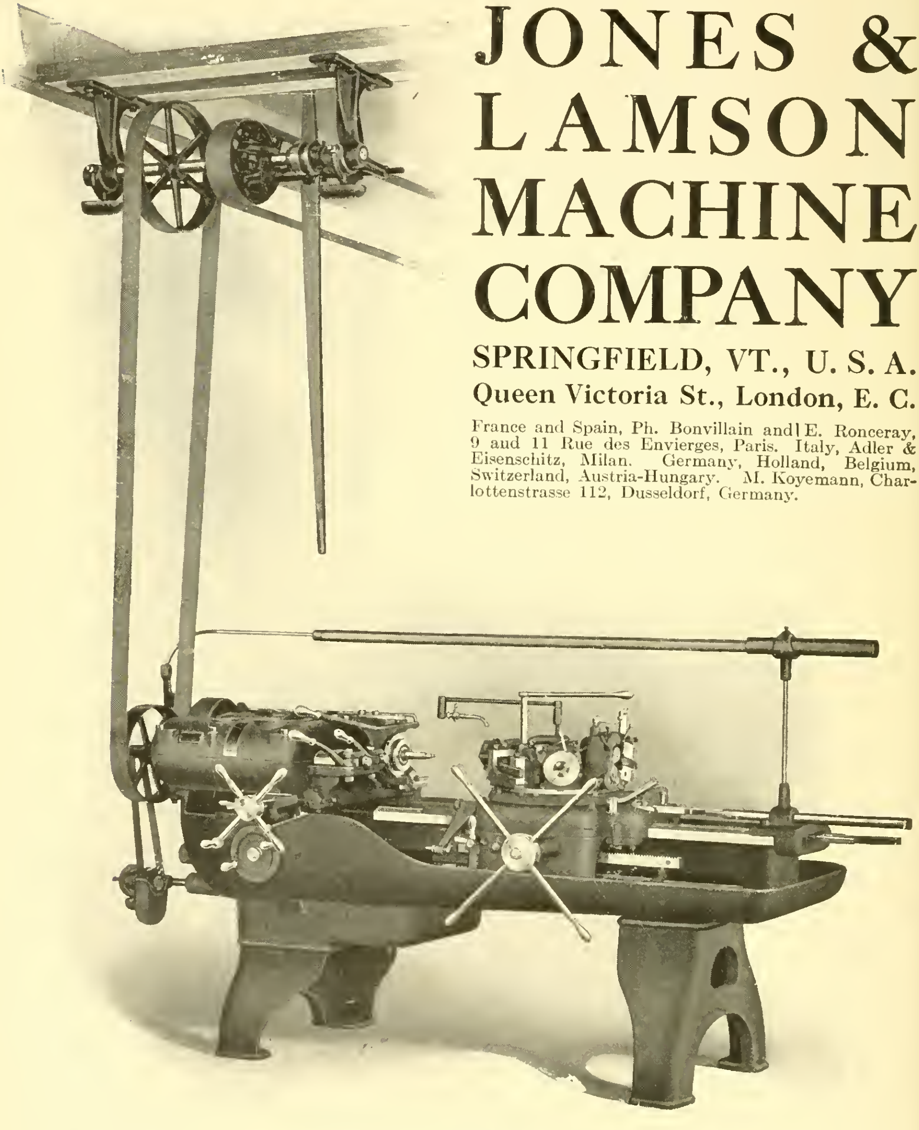

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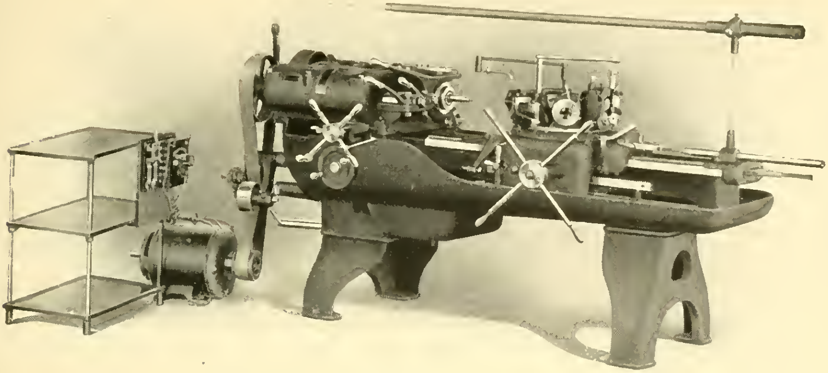

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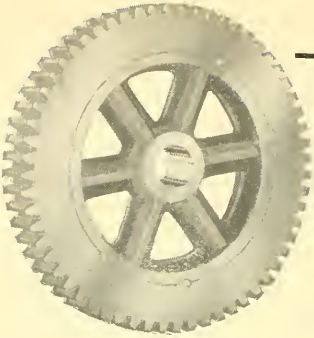

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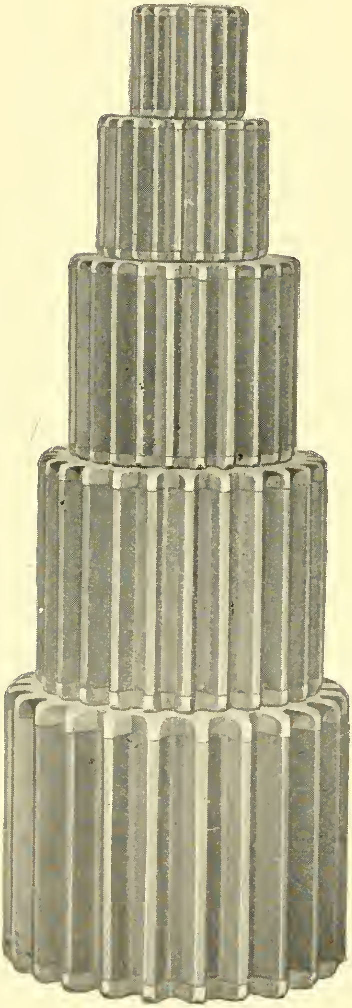

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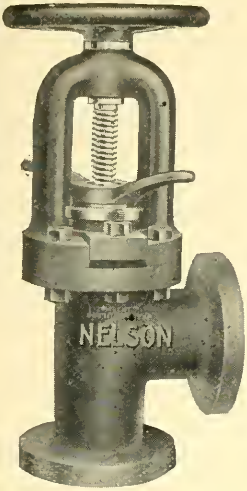
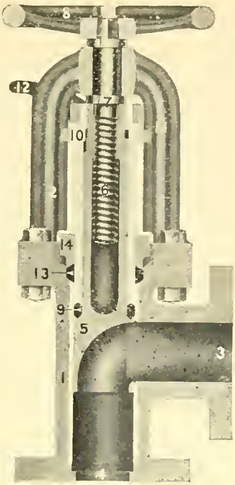


(Outside view.)



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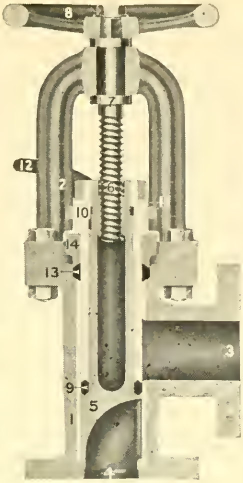

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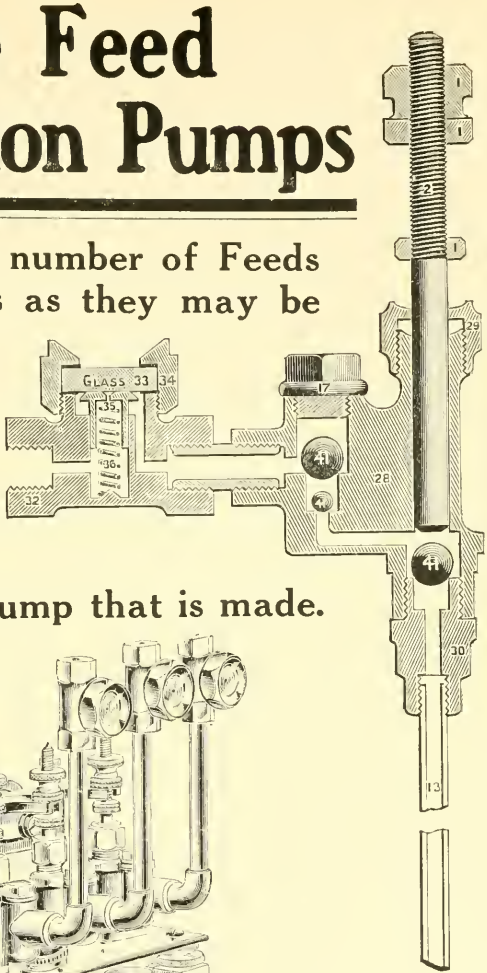

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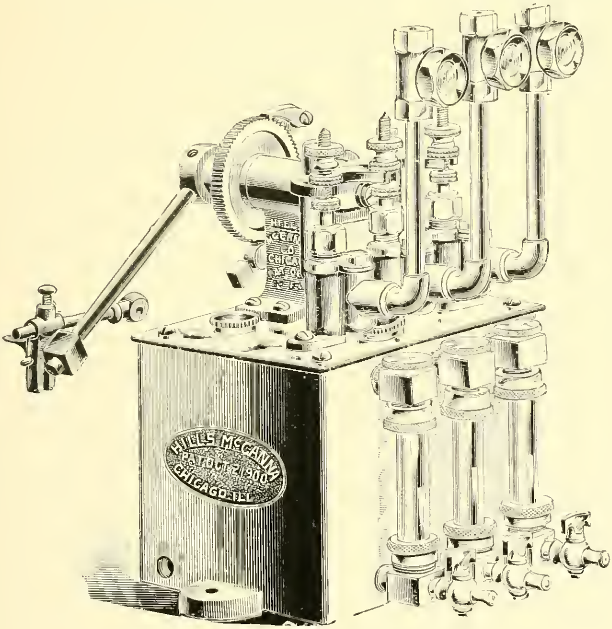

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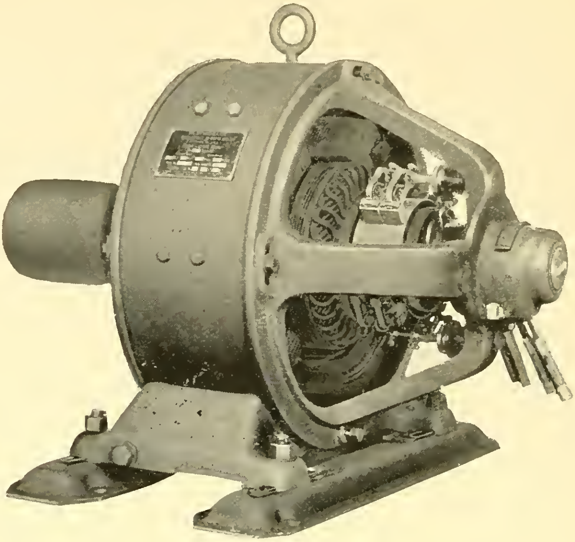

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This motor is particularly suited for steel mill machinery such as shears, saws, presses, straightening machines, machine tools, fans and pumps.

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Type SK motors are remarkably simple in construction, having few parts, all readily accessible. They are built in capacities ranging from 1½ to 250 horse power, and may be belted, geared or direct connected to the load. They are furnished with either open or semi-enclosed frames.

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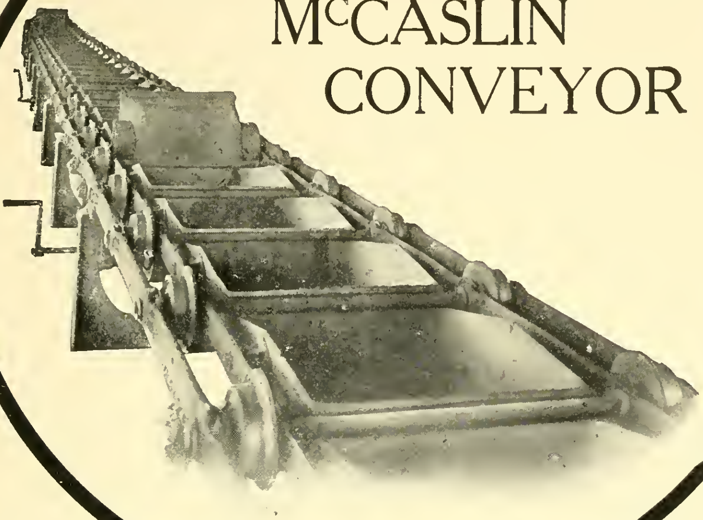

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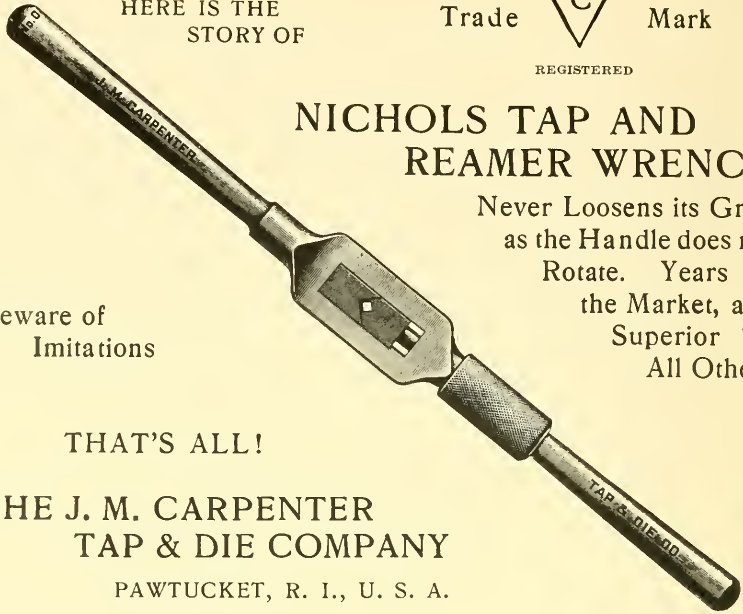

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Never Loosens its Grip,
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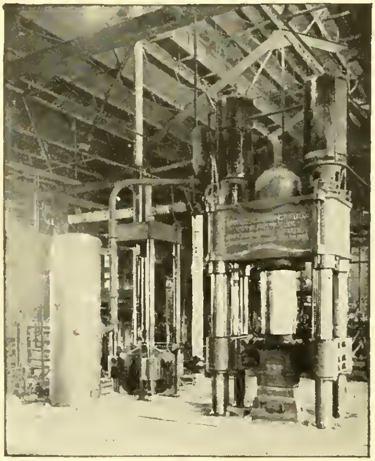
double your production with one-half your labor cost and steam consumption



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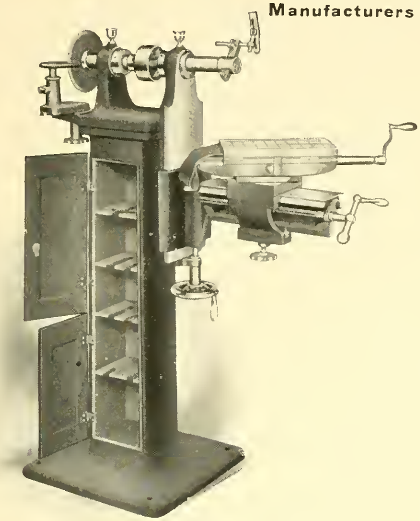

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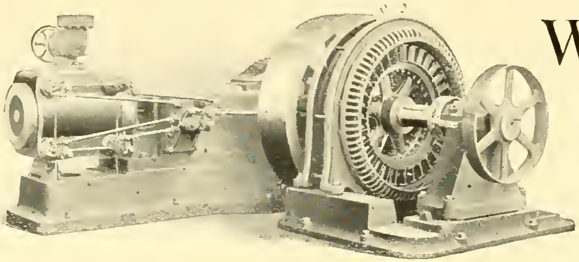

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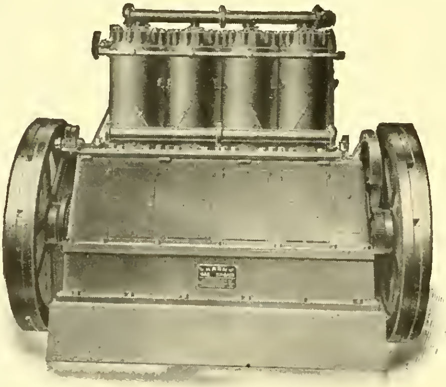

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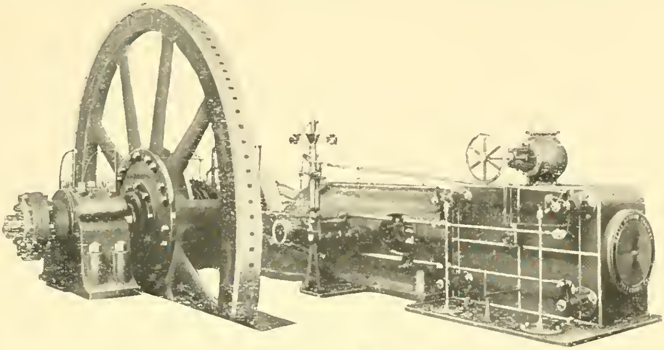

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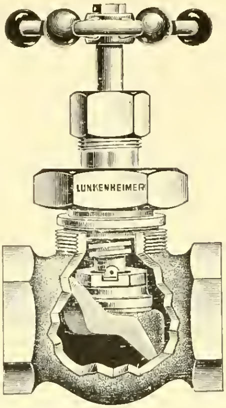

have invariably maintained a reputation for quality of the very highest. They are made by skilled mechanics, and the best grade of only new material is used.

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Lunkenheimer Regrinding Valves are made in Medium and Extra Heavy Patterns, for working pressures up to 200 and 300 pounds per square inch respectively.

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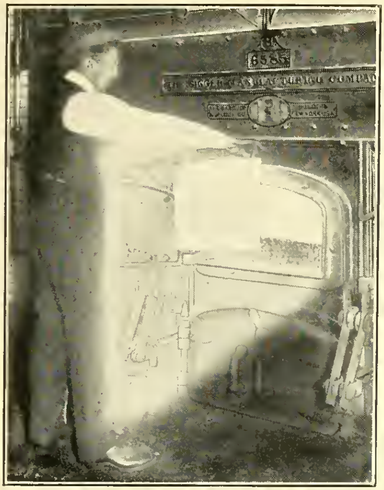
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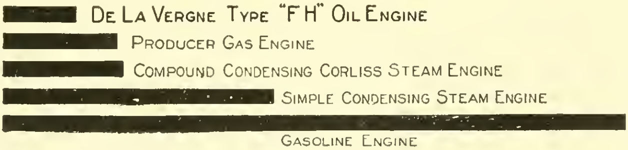
Relative Fuel Costs.



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The diagram above indicates the fuel cost of the De La Vergne Type "FH" Oil Engine in comparison with the fuel costs of various other heat engines. The lengths of the respective bars represent the cost of one B. H. P. per hour in cents.

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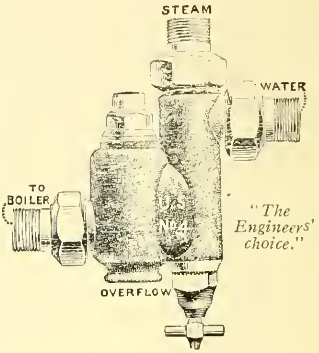
Drop us a card for a complimentary copy of the "Engineer's Red Book" telling all about U. S. Automatic Injectors and containing also a great deal of other information that is of vital importance to the Mechanical Engineer.



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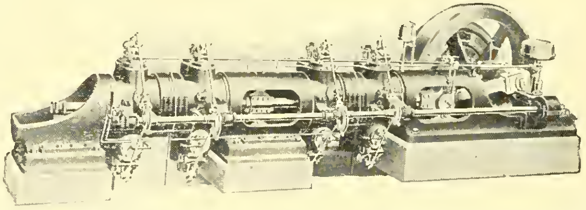

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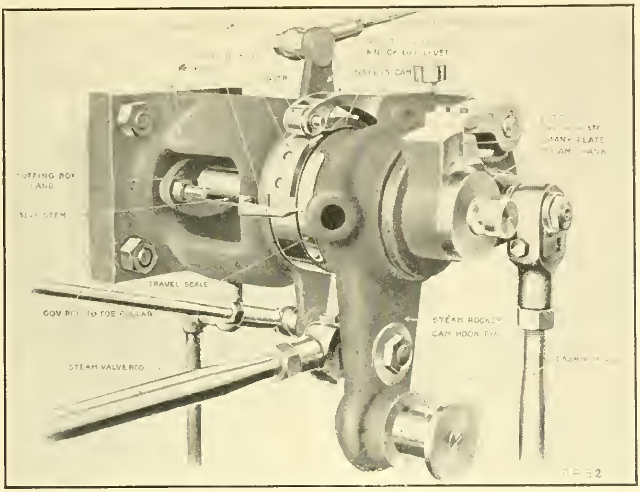
GAS **STEAM**

Hamilton Corliss Gravity Valve Gear



is the best on the market ***because:*** it is compact and simple and has few working parts—will operate noiselessly and positively at speeds up to 175 R.P.M.—is actually a gravity gear, the latch dropping into contact without the necessity of springs—the latch and cam levers are steel forgings, absolutely safe against breakage.

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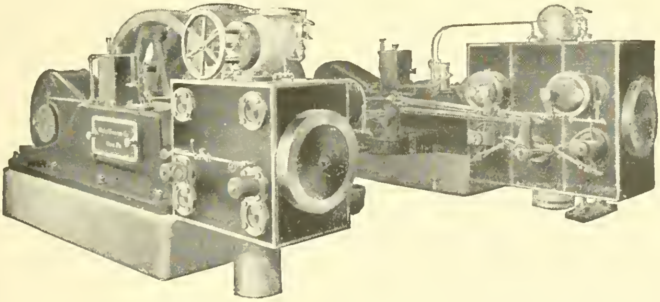

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With Non-Detaching Valve Gear

It was the drop cut-off gear which made the Corliss Engine successful and economical for slow speeds.

The feature which distinguishes our High and Medium Speed Engines and makes them superior to all other four-valve engines is our *patented non-detaching valve gear.*

This gear by positive action gives the valves the *same movement* that the *drop cut-off* of the slow speed Corliss *produces* by picking up and dropping them.

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The valves are given the movement necessary for the *greatest durability* and *tightness*, and the *best form* of valve is made possible.

This engine marks the extreme limit of excellence so far reached in economy and quiet running.

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ROTHCHILD ROTARY GATE VALVE

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SUPERIOR COMPARATIVE MERITS

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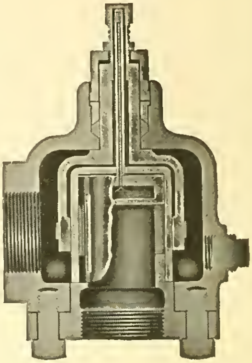

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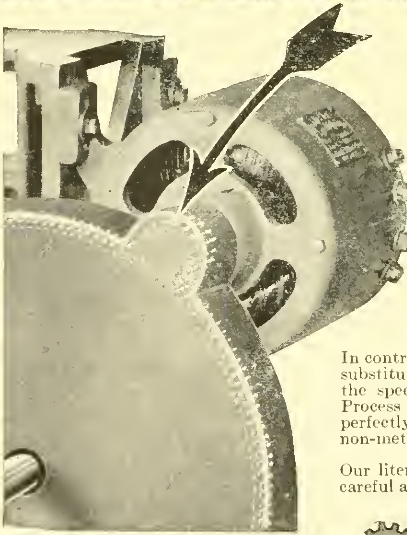

Metal Gear noises go right through a metal case.

You Can't Box Up Gear Noises

at least, not as easily as you can prevent them. You've probably seen hundreds of metal to metal gear drives, but no speedy ones that were not noisy. Perhaps while new, metal to metal drives may be quiet, but the penetrating ring and clatter will eventually come as sure as there is metallic contact. Enclosure within casings to prevent noise is only a makeshift. It does nothing to protect the machine parts from the harmful vibration that usually accompanies the noise.

In contrast, a drive with New Process Noiseless Pinion substituted for the metal one, is quiet no matter what the speed; it stays so without attention. New Process Pinions are unquestionably the strongest, most perfectly machined, most durable and most efficient non-metallic pinions made.

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NEW PROCESS IS TO ALL OTHER RAWHIDE AS STEEL IS TO IRON

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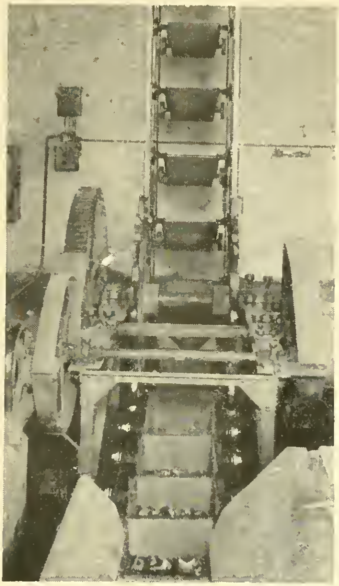

Handling Coal and Ashes Mechanically with Jeffrey Machinery at the Boiler House of the Erie Co., Pa. Electric Co.

Overlapping Pivoted Bucket Conveyer, 117 ft. between vertical centers, handles 50 tons coal per hour from track hopper to storage bins. Illustration shows the driving mechanism in the basement and lower run of conveyer. Ashes are delivered to the conveyer here, carried around the system in the same way as the coal, and dumped into ash chute by means of the traveling tripper, from which they are discharged to railroad car.

Write for Catalog No. 32, telling about the service of many Jeffrey Coal and Ashes Handling Equipments.

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Test the Goodrich Belts for the following essentials:
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Quality of cover. Test this by hammering and scraping with sharp material as well as by tensile strength and elasticity. Examine a

GOODRICH CONVEYOR BELT

Notice the improved edge construction which is the outcome of years of effort to overcome edge troubles.

Finally figure for yourself the importance of the selection of the proper duck to resist the strains and the deteriorating action of moisture; proper friction, to resist breaking down through years of life; the proper cover, to have the required adhesion, as well as life, and, above all, the proper combination of the belt.

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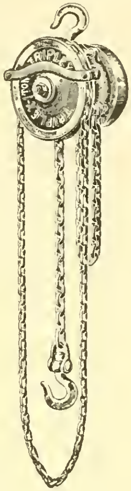

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IN England the chain block is classed with elevators, boilers and ships, as something on whose safety life depends.

It must pass a test, under the auspices of the Board of Trade, before its makers can sell it.

The same Triplex Block that you buy in America easily passes the test in England.

Every Triplex Block passes a more rigorous test in our works than is demanded by the British Board of Trade.

It is required by the law of our works at Stamford, Connecticut, and is a part of the system which has made the Triplex Block the world's standard lifting device.

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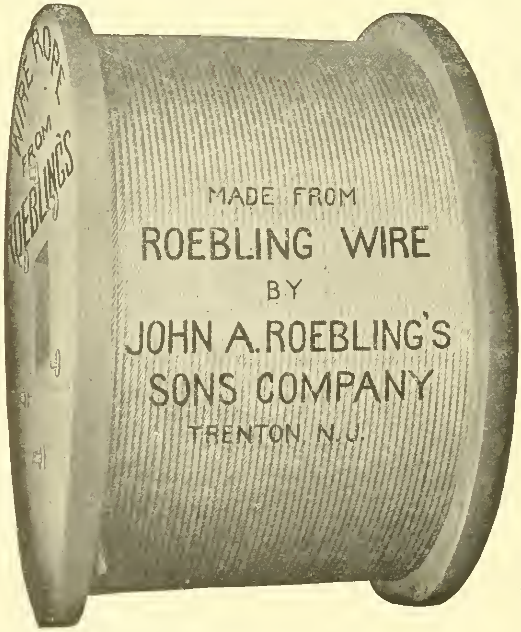

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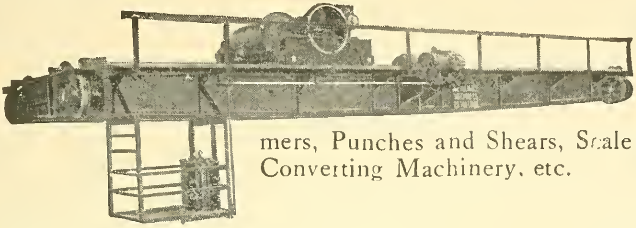

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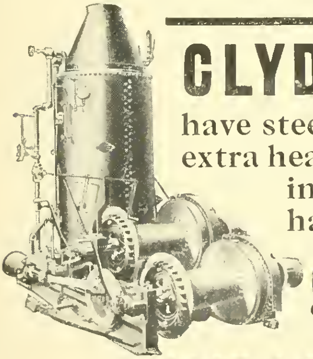

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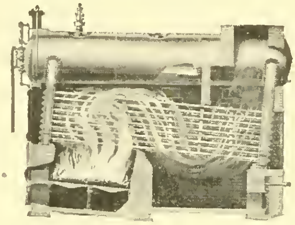

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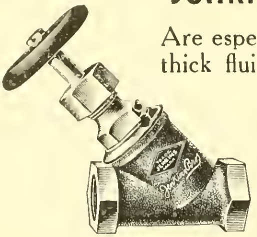
Jenkins Bros., Y or Blow-Off Valves



Are especially adapted for use where the unobstructed flow of thick fluids is required. As blow-off valves they have no superior. Having a full opening nearly in line with the pipe, but little resistance is offered to the free flow of steam or fluids. Fitted with Jenkins Discs, removable seat rings, and interchangeable parts throughout. Made in Brass or Iron Body. *Write for illustrated catalogue.*

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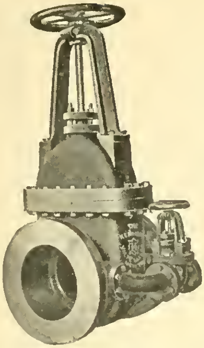

WE SPECIALIZE

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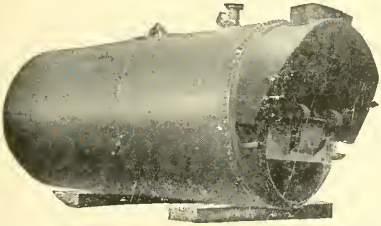

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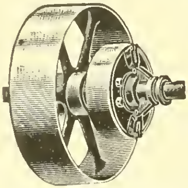

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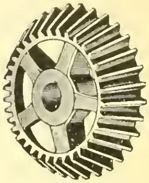

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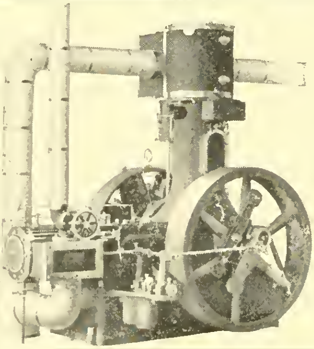

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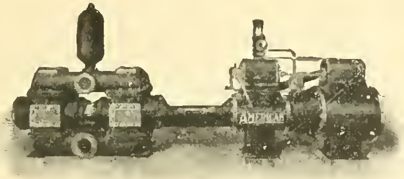

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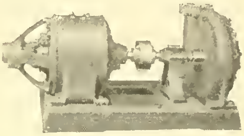

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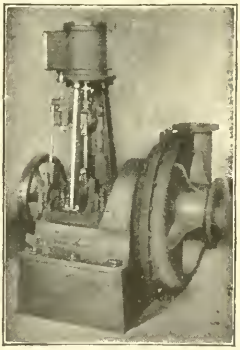

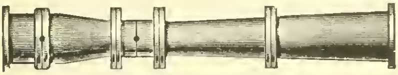

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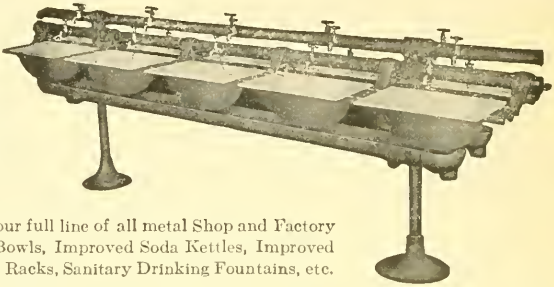

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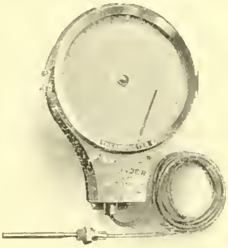

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THE
JOURNAL
of
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

APRIL 1912

35 CENTS A COPY $3 A YEAR

SPRING MEETING: CLEVELAND, OHIO, MAY 28-31
MONTHLY MEETINGS: NEW YORK, APRIL 9;
NEW HAVEN, APRIL 17; BOSTON, APRIL 26

THE VALUE OF YOUR MEMBERSHIP

in the Society is proportional to the number of representative men of the profession within the Society. The ideal organization would be one in which every engineer in good standing had been enrolled and which used the united efforts of its membership for the advancement of the arts and sciences within its field. The enormous industrial expansion of recent years has placed great responsibilities upon The American Society of Mechanical Engineers, *the society of the industries.*

Every effort is being made to discharge these obligations; but to insure the greatest usefulness, every engineer and executive in the industrial world should be enrolled.

The Committee on Increase of Membership invites your earnest coöperation in urging upon the leading men in each industry the moral obligation to join in the Society's work and the benefits to be derived from such participation. The Committee will assist by sending literature and application blanks and in other ways, but the personal interest of every member is essential to the proper conduct of the Society's work and the full discharge of its obligations.

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Geo W Melville

PRESIDENT 1899

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

APRIL 1912 VOL. 34 No. 4

THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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COMING MEETINGS OF THE SOCIETY

SPRING MEETING, MAY 28-31, CLEVELAND

MONTHLY MEETINGS

March 26, Providence, R. I., Narragansett Hotel, 6.30 p.m. Dinner of the Providence Association of Mechanical Engineers, affiliated with The American Society of Mechanical Engineers. Address: Review of Some Interesting Engineering and Commercial Features of the Land to the South of Us, E. L. Corthell.

March 30, Philadelphia, Pa., Engineers Club, 8 p.m. Paper: An Ideal Flour Mill, B. W. Dedrick, instructor in milling engineering, Pennsylvania State College. The Pennsylvania Millers Association will coöperate.

April 9, New York, Engineering Societies Building, 8.15 p.m. Meeting in honor of German Museum Commission, with addresses by some of its members.

April 17, New Haven, Conn., afternoon and evening, Mason Laboratory, Sheffield Scientific School. Paper: Development of Manufacturing in New England, Prof. J. W. Roe. Discussion: Scientific Management. Dinner, Yale Dining Club, 6 p.m.

April 26, Boston, Mass. Details of meeting to be announced later.

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 34 APRIL 1912 NUMBER 4

ISSUES OF THE JOURNAL WANTED

The Society wishes to secure copies of the following issues of The Journal: August 1911, October 1911, and January 1912. These will be purchased at 25 cents a copy. The January 1912 issue is especially desired.

SPRING MEETING IN CLEVELAND

The date for the Spring Meeting, previously announced for the first week in June, has been changed to the last week of May, opening on Tuesday, May 28, and closing on Friday, May 31. Every effort is being put forth by the local members in Cleveland and by the Committee on Meetings to make this one of the great conventions of the Society. The situation of Cleveland on the lake front, the variety and importance of its industrial works, and the attractiveness of the city as a whole all contribute to make it one of the most interesting cities in the country for a meeting of engineers. There is a large and enthusiastic body of engineers resident in the city to welcome the visiting members and their guests and to extend to them the hospitality for which the city is noted. The time at which the meeting is to be held is usually one of the most delightful in the whole year in this locality and everything points toward a most enjoyable occasion. The program committee have important arrangements in hand which they are at work upon but which are not far enough along to permit of announcement at the time of going to press. The plans for the reception of the visitors are having the personal attention of Past-President Ambrose Swasey, Chairman of the executive committee in Cleveland, Robert H. Fernald, Vice-Chairman, F. W. Ballard, Secretary, and R. B. Sheridan, Treasurer; besides the coöperation of Worcester R. Warner and S. T. Wellman, Past-Presidents, and other members who have been assigned to the various committees. The subjects that will come up for discussion at the professional sessions include recent developments in steam turbines, both here and abroad; modern flour-milling processes; important advances in the analysis of steam engine performance; hydraulic governing; recent data on the thermal properties of steam; data on the temperature of condensing water reservoirs; discoveries and new processes in chilling cast iron; and numerous other topics upon which papers are in prospect or have already been submitted. In fact, the Committee on Meetings is somewhat embarrassed by the wealth of material and a selection of papers will probably have to be made, having in mind the diversity of interests in the Society at large. A more complete statement of the subjects for discussion and of the program of arrangements will be made in the May number of The Journal. The essential part of the present announcement is the opening statement with regard to the change of date; with the further recommendation that every member within reach of Cleveland who can possibly attend reserve the four days from May 28 to May 31 for this purpose. Papers cannot be considered for the meeting later than April 15.

APRIL MEETING IN NEW YORK

The Society is to have the honor of entertaining at the time of the New York monthly meeting, April 9, the Commission of the German Museum of Munich of masterpieces of natural science and technical sciences, consisting of the following gentlemen: Dr. O. von Miller, Imperial Counsellor and President des Vereines deutscher Ingenieure; Dr. W. von Borscht, Lord Mayor, Privy Court Counsellor; Dr. W. von Dyck, Privy Counsellor Professor; Dr. Rudolf Diesel, Doctor of Engineering, inventor of the Diesel Engine, Herr Gelius, Constructing Architect, and Herr Schirmann, Director of the Library of the Museum.

It is expected that addresses will be made by certain of the visiting members of the Commission. This will be one of the most important meetings of the year in New York and postal-card notices will be issued later containing the detailed announcement.

During the month of April, honorary membership will be conferred upon Dr. Rudolf Diesel at a meeting to be held in the Engineering Societies Building, at which Dr. Diesel will probably make an address upon the Diesel Engine.

MEETING IN NEW HAVEN

As elsewhere announced, the members of the Society in New Haven have arranged a meeting for Wednesday, April 17, partaking of the nature of a convention, with afternoon and evening sessions. These will be held in the Mason Laboratory of Mechanical Engineering of the Sheffield Scientific School and the general topic for discussion will be Manufacturing Costs. The afternoon sessions will be devoted to a discussion of the development of manufacturing in New England, covering the production of typical New England products, such as hardware, firearms, typewriters, machine tools, and brass goods. In the evening the question to be brought forward for discussion will be the extent to which scientific management is applicable to small industries, a phase of the subject upon which definite information is much in demand. Dinner will be served at six o'clock in the Yale Dining Club.

This plan of holding all-day meetings of the Society is a noteworthy step in the extension of the Society's influence through meetings in various cities. An incident of this kind which should not be overlooked, is the annual meeting held by the student section of the Society at the University of Kansas, previously reported in these pages, where an entire day was devoted to professional meetings, an inspection of mechanical equipment and a dinner.

REQUEST FROM NEW YORK PUBLIC LIBRARY

The New York Public Library wishes to supplement its files of technical periodicals and similar collection of "Source Material" with the monographs and reports on various engineering enterprises that appear in print from time to time. Publications of this sort coming through periodicals and the regular book trade are bought by the Library; but the separate pamphlet reports that represent so large a part of the literature of this kind are not handled by the regular book trade and can be secured only through the courtesy and thoughtfulness of the engineers making such reports.

As most of our members know, the New York Public Library is almost adjacent to the Library of the Engineering Societies, and the most intimate coöperation prevails between the two institutions. It is therefore urged that all members broaden this friendly relation by contributing to the New York Public Library such reports as may be issued under their direction as well as to the Library in this building.

All documents of this kind are properly indexed and their preservation will be a lasting benefit to the donor as well as to the future student working along the same lines.

DISPLAY OF ERICSSON MODELS

On Saturday, March 9, the fiftieth anniversary of the battle of the Monitor and the Merrimac, a display of a series of models of inventions and scientific instruments made by Captain John Ericsson was opened to the public in the Engineering Societies Building. These models, which were made for the Centennial Exhibition in Philadelphia in 1876, subsequently came into the possession of Mr. George H. Robinson, and were presented by him in 1890 to the Metropolitan Museum of New York, which in 1907 gave them to the United Engineering Societies. They include a model of parts of the Monitor engine, showing the rockshaft, a globe actinometer, a solar calorimetor, a caloric engine, a galvanometer, a portable solar calorimeter, an aero-steam engine, a galvanometer cone, the rotary gun-carriage and transit platform of the Spanish gunboat Torpedo, made in 1873, the parallactic mechanism for measuring radiation of parts of a solar disk, a distance instrument for measuring distances at sea, made in 1841, and a dynamic register for measuring the relative power of currents of water and vapor, in addition to three cups, made respectively from the wood of the Congress, the Merrimac and the Cumberland, and presented to Captain Ericsson by the United States Government. A wooden model of the Monitor, the property of the Society, was also shown. This was presented to the Society in 1893 by Thomas F. Rowland, the builder of the Monitor at the Continental Iron Works.

John Ericsson became a member of the Society in 1882, and though offered honorary membership as well as other honors, he steadfastly refused to be so ranked, preferring to be considered simply as an active member. An interesting account of his life appears in Transactions Volume 10.

The Society also has in its possession a fine painting of Ericsson which has an interesting history. In 1862 the artist Ballin of Stockholm, knowing Ericsson's aversion to sitting for a portrait, but being desirous of painting the great engineer, secured several interviews with him under the guise of a promoter of an alleged invention for an expansive bullet. During these interviews, he was able to fix the features of Ericsson so in his mind that he could afterwards reproduce them perfectly on the canvas. When the painting was completed he called upon Ericsson, carrying his masterpiece under his arm, only to be driven out into the street.

In 1895 the portrait was discovered by Professor F. R. Hutton, Secretary of the Society, in the rooms of a second-hand dealer, and was purchased and presented to the Society. The artist afterward called at the rooms of the Society and positively identified the picture. In 1865 the picture was presented to the Sanitary Fair held in Brooklyn, the proceeds of which were devoted to the hospital wards, and was purchased by Aaron Claflin, and later sold at auction in the Willoughby Street Auction Rooms, Brooklyn. It is possible that this is the portrait which was purchased by New York citizens and subsequently presented to Captain Ericsson. The painting, which is bust length, shows clearly Ericsson's strong and masterful features, with a glimpse also of those qualities as a dreamer which made him a great inventor.

The Society owns also a fine bust of Ericsson, made by John Kneeland, and presented by James M. Dodge, Past-President.

FOREIGN REVIEW

Attention is called to the new section of The Journal, The Foreign Review, which has appeared in the issues of this year.

The object of the Review is to show what the engineering world is doing in the non-English speaking countries, and it is made possible through the large number of foreign periodicals received in the Library of the Engineering Societies, numbering some two-hundred and twenty. These periodicals are gone over day by day as received and brief abstracts of the leading articles made in English, giving, where possible, engineering data, formulæ, tables, etc. Reference is made to publications in the English language, if such exist, containing fuller information on the subject treated. Measures are given both in original units and English equivalents and, wherever practicable, drawings are reproduced from the original articles.

The Review has necessarily been started in a small way, but the

Publication Committee hope to increase its scope and usefulness as the income of the Society permits. Inasmuch as but few engineers have these foreign periodicals at their disposal without a visit to a library, it is believed that the publication of this matter in The Journal will be welcomed by the membership with the ultimate result of extending very materially the usefulness of the Library of the Engineering Societies to those residing in different parts of the country. Suggestions are solicited for making the Review better and more useful. In connection with this work, also, the library offers to supply complete translations of foreign articles at moderate cost.

VISITS BY THE SECRETARY

Supplementing the tour of student branches made by the Secretary the early part of the year, a visit was made on March 13 to the Rensselaer Polytechnic Institute, where the Secretary spoke to the membership on the advantages of student engineering societies.

On March 15 a meeting of the Student Branch at Cornell University was held in the afternoon, and in the evening the annual Sibley Banquet, both of which were addressed by the Secretary. Cornell has the largest branch affiliated with the Society and its membership is enthusiastic and wide-awake. Six hundred guests attended the banquet, which was also addressed by Prof. C. F. Hirshfeld of the department of mechanical engineering, Prof. C. L. Durham of the department of arts and sciences, Judge Irvine of the Law School, and L. A. Osborne, vice-president of the Westinghouse Electric & Manufacturing Company. The arrangements for the occasion were in charge of D. S. Wegg, chairman of the committee and secretary of the branch. A clever program had been prepared for the occasion and each guest was also presented with a number of fine souvenirs, the gift of various manufacturing firms.

On Monday, March 18, the Secretary attended a smoker given by the members of the Society in Pittsburgh and conveyed to them the belief of the Council that the Engineers Society of Western Pennsylvania was adequately providing for the present needs of the membership for meetings in Pittsburgh. He also expressed the desire of the Council and of the Society to coöperate with them in every way.

The Student branch at Pennsylvania State College was visited by the Secretary on March 19. A meeting of the branch was held in the afternoon and in the evening the Secretary addressed the student body on the Relation of the Engineer to the Public.

ELECTIONS TO HONORARY MEMBERSHIP

At the February Meeting of the Council the President announced the election to Honorary Membership of Anatole Mallet, Paris, France; Dr. Carl Gustav Patrick De Laval, Stockholm, Sweden; and Dr. Rudolf Diesel, Munich, Germany.

M. Mallet has been engaged on various mechanical questions since 1867, among which are steam engines with double expansion and the application of this system to locomotives. The first application was realized in 1875 on the locomotive of the Bayonne and Biarritz Railway; and afterwards on the locomotives of railways of Southwest Russia, of Austria, of Spain and Switzerland. Since 1884, M. Mallet has studied the type of articulated compound locomotives, which has been applied to small locomotives with four axles of 12,000 kg. up to the enormous locomotives with 12 axles of which ten are grinding axles and of a weight of 250,000 kg.

Dr. De Laval in his earlier years did important work in developing processes for the manufacture of steel; but is best known through his invention of the centrifugal cream separator and other apparatus for the use of dairies. The necessity of a high-speed motor for driving the cream separator led to the invention of the De Laval steam turbine with its various characteristic features such as the flexible shaft and gear drive. His inventions have materially helped Sweden to become a great agricultural country and have assisted in disposing of its products to other countries.

Dr. Diesel is widely known as the inventor of the Diesel engine, which he described in a paper read before the National Society of Engineers of Germany in 1897, and which has since been taken up in every country, so that today thousands of Diesel engines are in operation, ranging from 20 to 500 h.p. Dr. Diesel is a member of the Franklin Institute and was decorated with the Order of St. Michel in the third Class.

MEETING OF THE COUNCIL

At the meeting of the Council for March a report by A. M. Hunt of San Francisco was presented of the Convention recently called in San Francisco to formulate plans for the organization of an International Engineering Congress in connection with the Panama Pacific Exposition in 1915, and an invitation extended to this Society to hold its Spring Meeting in that year in San Francisco.

The Council passed a resolution accepting this invitation, the meeting to be the regular Semi-Annual Meeting of the Society, and voted that an invitation be extended to representatives of foreign societies of like character to join in this meeting.

It was also voted that a Committee be appointed by the President to take up the subject of standard cross-sections and symbols for refractories, as embodied in the paper of H. De B. Parsons given at the Annual Meeting, and suggested further by Bradley Stoughton of New York.

The Council further voted, in view of an invitation of the New England Water Works Association asking this Society and the National Association of Master Steam and Hot Water Fitters to join with them in extending the standardization of flanges for pipes up to and including eighty-four inches, that the former Flange Committee be reappointed. As a result it is expected that the recent work of this Committee will be extended and a rational basis for further standardization be finally recommended.

CODE OF ETHICS FOR ENGINEERS

The board of directors of the American Institute of Electrical Engineers have adopted a code of ethics for the professional conduct of engineers. It takes up first a statement to the effect that the engineer in his relations should be guided by the highest principles and that he should satisfy himself to the best of his ability that the enterprises with which he becomes identified are of a legitimate character. It then discusses under suitable divisions the engineer's relations to client or employer; the ownership of engineering records and data, considering employer and client, or customer as well as the engineer; the engineer's relation to the public; and the engineer's relations to the engineering fraternity. This statement of principles is to be published in full in the Proceedings of the American Institute of Electrical Engineers.

RESUSCITATION FROM ELECTRIC SHOCK

The first meeting of the Commission on Resuscitation from Electric Shock was held in the board room of the National Electric Light Association, New York, on February 22. This commission was organized upon the initiative of the National Electric Light Association, and has for a purpose the study of electric shock and the preparation of a set of rules for first aid in case of electrical accident. The commission is composed of members of the American Medical

Association, National Electric Light Association and American Institute of Electrical Engineers.

At the meeting in New York City the medical members of the commission unanimously advocated the Schaefer, or prone, method as the best means in the hands of laymen for maintaining respiration in victims of electric shock, and the commission formally voted to recommend this method. A chart is now being prepared which will give details of first aid in cases of electric accidents and will describe fully the method of applying artificial respiration. This chart will be issued under the auspices of the National Electric Light Association.

GEORGE WALLACE MELVILLE

A career which has added luster to the entire engineering profession was brought to a close on March 17, 1912, in the death of Rear-Admiral George Wallace Melville, U. S. N. Retired, at his home in Philadelphia, Pa., after a brief illness.

Born of Scotch parentage illustrious for its bravery, George Wallace Melville was one of the first to volunteer in his country's service at the outbreak of the Civil War. In 1804, James Melville of Sterling, Scotland, had come to New York, bringing with him his family, one of whom, Alexander Melville, a chemist, became the father of the noted engineer. George Wallace, oldest son of Alexander and Sarah Douther Wallace Melville, was born in New York on January 10, 1841, educated in the public schools, and showing early mechanical ability, sent to the Polytechnic School of Brooklyn and, later, to a religious academy noted for its excellent mathematical training. He had entered the engineering works of James Binn in East Brooklyn, and had acquired the foundation for that practical skill which served him so well in many a later event, when war was declared.

Melville was at once appointed an officer of the Engineering Corps of the United States Navy, for which he was well fitted despite his extreme youth, and throughout the war saw almost continuous service. He will perhaps be best remembered for his daring work in connection with the capture of the Confederate cruiser Florida in the neutral waters of Brazil—a breach of international law, but a justifiable and clever strategy.

The war ended, Melville's adventurous spirit soon sought for new foes to conquer, and when in 1873 the sealing steamer Tigress was chartered to rescue the remnant of Captain Hall's last and fatal voyage to the Arctic, Melville volunteered as her engineer officer. The White North proved an antagonist worthy of Melville's bravery and skill, and it was for his share in the long struggle with the enemy, conquered only within the past two years, that his name first became honored throughout the civilized world. When in 1879 the Jeannette, commanded by Lieut. George W. De Long, embarked upon an expedition to the North Pole through Bering Strait, hitherto an untried route, Melville was of the staff, although the department reluctantly assented to his assignment because of the difficulty of filling his place. On the voyage he was called by De Long "a tower of strength," "always self-helpful and reliant in emergency," "of indomitable energy," yet ever cheerful and with a smile and word of encouragement for all. "When he does retire," says De Long, in the time of crisis, "he lies awake, planning some new means of pumping a ship by steam which will be more economical than the main boilers."

Such planning was much needed, for soon after leaving California the vessel was caught in the ice and never after escaped from the floe which held her. In 1881, Melville manned a small force sent by De Long to plant the American flag on what is now known as Henrietta Island, which proved a most hazardous undertaking and which has been most graphically described by Melville himself in his book, "In the Lena Delta." After a three days' journey of constant danger and struggle with the moving ice, hindered by various mishaps and by the frightened dogs, the island was triumphantly claimed for the American government. Of this feat De Long says: "If this persistence in landing upon this island, in spite of the superhuman difficulties he encountered, is not reckoned a brave and meritorious action, it will not be from any failure on my part to make it known."

On June 7, 1881, the Jeannette, worn out with the crushing force of the moving ice, went down, leaving her crew upon the floe, the nearest source of food 500 miles away in the Lena Delta, and the nearest known land, the desert New Siberian Islands, 150 miles distant. For forty-one days they toiled on, Melville ever ready to aid the sick and discouraged and full of energy and expedients. At length coming upon an island hitherto unknown, now called Bennett Island, they rested for nine days and then when the Arctic winter was setting in, embarked southward in three boats, commanded respectively by De Long, Chipp and Melville. Separated by a terrific storm, Melville's crew were finally brought to port, alive but in a pitiable condition. Chipp's vessel had gone down in their sight, a victim of the waves; De Long's fate they could only conjecture. Instead of pushing his way southward, "whither," as Bennett says in The Steam Navy of the United States, "a warmer sun was shining and where lay the great Russian road leading to the borders of civilization, to the railway, to the blue sea, to home," Melville set out to find De Long, who in his own heart he feared had perished. "Few men," says Bennett, "after passing through all the perils that Melville had survived, would have thrown away that seeming last chance of personal safety, but he, being cast in rare, heroic mould, turned his back upon the means of saving himself and set his rugged face to the northward, forcing his way into the darkness and the awful silence of the Arctic winter like one deliberately invading the dominions of death."

How Melville pressed forward, weak and footsore, suffering from cold and exposure, quelling the mutinies of his native companions from time to time, only to fail in his quest; how, when spring came, he went forth undaunted a second time, to discover at last the bodies of the brave De Long and his party and to bury them, as he has himself written, "in the sight of the spot where they fell, the scene of their suffering and heroic endeavor, where the everlasting snows would be their winding sheet, and the fierce polar blasts would wail their wild dirge through all time,"—is now a matter of common knowledge and need not here be more fully recounted.

In the spring of 1884 Melville made his last trip to the North, this time with the Greeley relief expedition, and was one of the first to reach the dying men at Cape Sabine, a fit ending to this chapter of his career.

The Government had not been unmindful of Melville's broad knowledge of engineering and his intrepid spirit, and in 1887 when the new Navy was in process of building, Admiral Melville was appointed Engineer-in-Chief with the relative rank of Commodore.

At this time the four Roach Cruisers had been completed and contracts had been placed for a few of the succeeding vessels. Except for these few, however, the machinery of the new Navy was all designed by Melville or under his supervision until the time of his retirement sixteen years later. Even this does not represent the total amount of designing done by the Bureau under his direction, since the work was so radically new that tentative designs had to be prepared in many cases, which subsequent changes in the general features of the vessel caused to be given up.

Machinery aggregating more than 1,000,000 h.p. was designed and built under his supervision for vessels of all types from battleships to torpedo boats, involving millions of dollars. He was the first engineer-in-chief to advocate and actually install water tube boilers. The first to be thus fitted out was the Monterey, equipped with Ward boilers of about 5,000 h.p. He also adopted water tube boilers exclusively for sea launches with the best results, but did not allow himself to be carried away unduly with the idea. He felt that the best interests of the Navy required that the first boilers installed be tested thoroughly before adopting this type as a settled policy.

Ever vigilant to keep our Navy in the forefront of progress he consistently demanded highest possible speed in vessels of all types. In 1898, when other nations were building large battleships of 18 knots speed or over, it was proposed by the Navy Department to construct new vessels copied after the slower 16-knot battleships of previous years; but the Admiral's determined stand and the willingness of contractors to furnish ships capable of attaining the higher speed enabled us to get vessels of 18 knots. As another evidence of this policy, reference should be made to the two triple-screw flyers, Columbia and Minneapolis, which were the first very large vessels to be equipped with triple screws, each vessel developing about 20,000 h.p. and breaking the speed record for naval vessels larger than torpedo-boats at that time. This was one of the boldest pieces of designing which has been done in the Navy Department and is but another evidence of the courage and foresight displayed by Melville upon all occasions where progressive action was demanded.

He applied the method of testing the speed of vessels now known as the "Standardized Screw," and at the time of his retirement had completed an extensive investigation of the use of fuel oil on shipboard.

In the war with Spain, bitterly opposed by Melville with all his customary strength of opinion, his foresight and determination were nevertheless responsible for the equipment of Key West as a naval base and the sending out of the Vulcan, the first repair ship to be used in warfare.

In 1899 came the culmination of the long fight which the engineers in the navy had made to secure actual rank as naval officers instead of relative rank with professional titles. Inasmuch as their work has come to be largely executive, involving the command of a considerable portion of the ship's company, the engineers felt that they should have title commensurate with their duties. This was opposed for years by the line officers, but the splendid work of the

Engineer Corps under Melville and his own personality brought about a better feeling and the Personnel Board was appointed, presided over by Assistant Secretary of the Navy Roosevelt. The result of the deliberations of this board was a reorganization of the entire personnel of the navy, which consolidated the engineers with the line. It cannot be doubted that the work and bearing of Melville and the accomplishments of his department were largely responsible for this sweeping change.

In 1903 Admiral Melville retired from the service in accordance with the sixty-two year limit, though still active and vigorous both mentally and physically, and several years later opened a consulting office in Philadelphia in partnership with J. H. Macalpine, the joint inventor with him of the steam turbine reduction gear for ship and other purposes, which has been described in their book upon the subject, "Broadening the Field of the Marine Steam Turbine," published in 1909. Just before the close of his administration an elaborate series of tests on the use of fuel oil was made under his direction by the U. S. Naval "Liquid Fuel" board, and published as a public document.

Throughout his life Melville's inventive genius was constantly in evidence and there is a long list of inventions to his credit during his work as an ordnance engineer which were never patented. In later years he made numerous patented inventions.

Admiral Melville was justly the recipient of many honors. On his way home from the Jeanette expedition he was granted a private audience by the Czar and Czarina of Russia and was made a Knight of St. Stanislaus of the First Class. Congress in 1900 conferred upon him a gold medal for his heroic service in the Arctic regions and advanced him a grade. He was an honorary member of the Royal Swedish Society of Anthropology and Geography, a member of the National Geographical Society of the United States, the Geographical Society of Philadelphia, the Philosophical Society, the Washington Academy, the Naval Architects and Marine Engineers, and an honorary member of Franklin Institute and of the American Society of Civil Engineers. He was subsequently made also an honorary member of the Institution of Naval Architects of Great Britain, and honorary degrees were conferred upon him by a number of colleges. His service in the Civil War made him a member of the Grand Army of the Republic, of the Naval Order of the United States, and of the Military Order of the Loyal Legion, composed of commissioned officers of the war. By the latter he was shown much honor and was at the time of his death Commander of the Pennsylvania commandery and Commander-in-Chief of the Order. Some years ago the Loyal Legion placed a fine bust of Admiral Melville, done in bronze, in the Philadelphia Museum.

Admiral Melville became a member of the Society in 1893 and was elected to honorary membership at the Spring Meeting of 1910, held at Atlantic City, where he delivered an address on The Engineer's Duty as a Citizen. From 1895 to 1897 he was a vice-president of the Society and in 1898 became its president, filling the office with much distinction, and giving an interesting account of Engineering in the United States Navy, its Personnel and Material, as his presidential address at the Annual Meeting of 1899. When the Society held its meeting in Washington, D. C., in the spring of 1909, one of its prominent features was an address on the Engineer in the Navy delivered by Admiral Melville, followed by the presentation of his portrait, painted by Sigismond de Ivanowski, to the National Gallery. On the occasion of his seventieth birthday, a number of Admiral Melville's friends presented him with a silver platter of fine workmanship and a memorial resolution, handsomely engrossed, which now hang in the rooms of the Society. The Society was represented at Admiral Melville's funeral on March 20, 1912, by Honorary Vice-Presidents Walter M. McFarland, James M. Dodge, Past-President, Coleman Sellers, Jr., and Theo. N. Ely.

A DISCUSSION OF CERTAIN THERMAL PROPERTIES OF STEAM

By G. A. Goodenough

ABSTRACT OF PAPER

The trustworthy data furnished by the Munich experiments on various properties of steam are used as the basis of a general theory. The characteristic equation proposed by Linde is slightly modified and by means of the Clausius thermodynamic relation a formula for specific heat is derived. The resulting specific heat curves are subjected to various tests and the validity of the formula is apparently established. With the aid of the general equation of thermodynamics explicit expressions for the heat content, energy, and entropy of superheated steam are deduced. The values obtained from these formulae are compared with corresponding values in the Marks and Davis table, and substantial agreement is shown.

A DISCUSSION OF CERTAIN THERMAL PROPERTIES OF STEAM

By G. A. Goodenough,[1] Urbana, Ill.
Non-Member

The recent paper[2] by Dr. H. N. Davis on the thermal properties of steam covers the ground so completely that any further contribution may seem superfluous. In one phase of the investigation, however, he acknowledges some lack of success and leaves unsolved a single problem. He says on page 303, "The reconciliation through Clausius' thermodynamic relation of the accepted volume and specific heat measurements in the superheated region is impossible. It is probably the most important of the outstanding problems in the field." It is the purpose of this paper to present an attack on the problem thus suggested.

2 The Clausius relation referred to is expressed by the equation

$$\left[\frac{\partial c_p}{\partial p}\right]_T = -AT\left[\frac{\partial^2 v}{\partial T^2}\right]_v$$

The relation is readily derived from the general equations of thermodynamics, and is applicable to all substances. The derivative in the second member is obtained from the characteristic equation $\phi\ (p,\ v,\ t) = 0$ of the substance under consideration. If an expression can be found for this derivative from a sufficiently accurate characteristic equation, the rate of variation of specific heat c_p with the pressure is determined; and if sufficient experimental data are available, it should be possible to derive an explicit expression for c_p in terms of the variables p and T. The method has inherent difficulties, as

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[1] Professor of Thermodynamics, Univ. of Ill.

[2] Notes on Certain Thermal Properties of Steam, H. N. Davis. Proc. Am. Acad. of Arts and Sciences, vol. 45, pp. 268–311.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

pointed out by Dr. Davis, and so far it has been used with little success.

3 In the following sections an attempt is made to apply the Clausius relation in the case of superheated steam and to reconcile the volume measurements of Knoblauch, Linde, and Klebe with the specific heat measurements of Knoblauch and Jakob, and of Knoblauch and Mollier. The discussion is divided as follows:

a The characteristic equation for superheated steam proposed by Linde is modified without any material sacrifice in accuracy.

b From the modified equation an expression for the specific heat c_p is derived, and the constants are so chosen that the specific heat curves represent quite accurately the results obtained by Knoblauch and Jakob, and Knoblauch and Mollier.

c From the equation for c_p thus developed, explicit equations for the heat content, entropy and energy of superheated steam are derived.

d The values of volume, heat content and entropy deduced from these equations are compared with the values given in the Marks and Davis tables, and substantial agreement is shown.

THE CHARACTERISTIC EQUATION

4 The experiments of Knoblauch, Linde and Klebe furnish reliable data for a characteristic equation connecting the pressure, temperature and volume of superheated steam. To represent these experiments, Linde [1] proposed in the first instance the equation

$$pv = BT - \left[C\left(\frac{373}{T}\right)^2 - D\right]\frac{1}{v} \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

but for the sake of convenience in calculation adopted finally the equation

$$pv = BT - p(1+ap)\left[C\left(\frac{373}{T}\right)^3 - D\right] \quad \ldots\ldots [2]$$

Linde gives for the constants of [2] the following values (metric units):

$$B = 47.10;\ a = 0.000002;\ C = 0.031;\ D = 0.0052$$

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[1] Mitteilungen über Forschungsarbeiten, vol. 21, 1905.

It appears, however, that these constants can be changed somewhat without affecting materially the agreement of the calculated and experimental results. Linde himself calls attention to an objection to the assumed form of the equation which lies in the fact that at a temperature of about 402 deg. cent., the "correction term" of the second member changes sign, and for higher temperatures the fluid becomes a "more than perfect" (übervollkommenes) gas. He suggests in this connection that the objection may be obviated by increasing the exponent of T from 3 to 3.5, the value assumed by Callendar. The integral value 3 was retained, however, for the sake of convenience in computation.

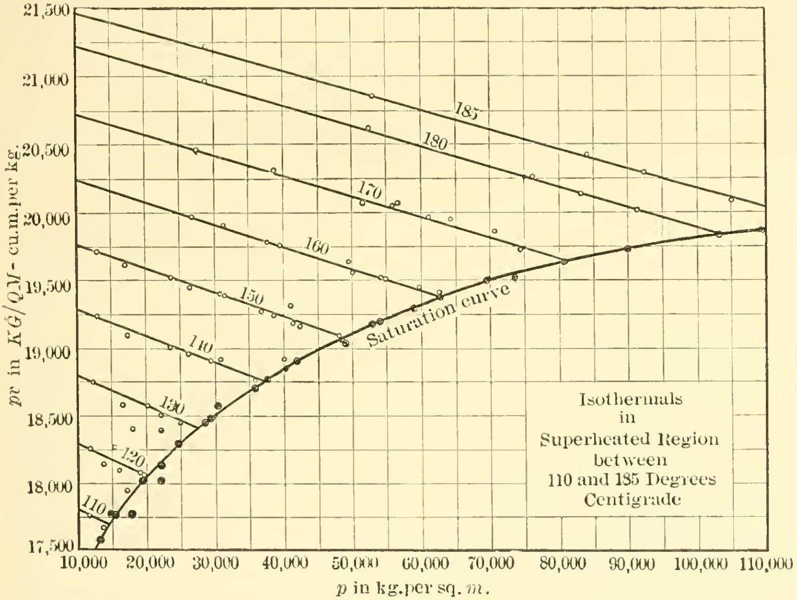

Fig. 1 Comparison of Isothermal Curves deduced from [3] with the Points representing the Experiments of Knoblauch, Linde and Klebe

5 Close inspection of Linde's equation shows that its form is such as to render it somewhat inconvenient for purposes of computation. The essential feature of the formula is the factor $(1+ap)$ which gives the parabolic form to the isothermals when drawn on the pv-p plane. If this be retained, considerable liberty may be taken with the remaining constants without materially affecting the integrity of the equation. In the first place, if the exponent n

be raised from 3 to 3.5, the constant D may be dropped entirely. The equation is then free from Linde's objection that the correction term changes sign at high temperatures, and with constants properly chosen gives results that represent satisfactorily the Munich experiments.

6 In the investigation of other properties of superheated steam, heat content, entropy, etc., considerations appeared that rendered desirable further modification of Linde's equation. The exponent n was raised to 5 and a constant was added to the volume v. The equation therefore took the form:

$$p(v+c)=BT-p(1+ap)\frac{m}{T^n}\dots\dots\dots\dots\dots\dots[3]$$

7 The following are the constants finally chosen for this equation:

METRIC UNITS	ENGLISH UNITS
$B=47.113$	$B=85.871$, p in lb. per sq. ft.
	$=0.5963$, p in lb. per sq. in.
$\log m=11.19839$	$\log m=13.67938$
$n=5$	$n=5$
$c=0.0055$	$c=0.088$
$a=0.00000085$	$a=0.0006$, p in lb. per sq. in.

8 With these constants equation [3] represents the results of the Munich experiments with substantially the same accuracy as Linde's equation. In fact, when the isothermal curves are drawn on a pv-p chart, as in Fig. 13 of Linde's discussion, the agreement between the curves and experimental points is in some respects better than that given by Linde's equation. The isothermals thus drawn are shown in Fig. 1, which may be compared with Linde's Fig. 13. For a further test of equations [2] and [3], showing that the latter equation may be accepted with confidence at the saturation limit, see Appendix No. 1.

9 As the experiments of Knoblauch, Linde and Klebe extended to only 185 deg. cent., the validity of [3] for higher temperatures is uncertain. It is a safe assertion, however, that [3] is more suitable for extrapolation to high temperatures than is the original Linde equation, but it is possible that equation [3] does not hold at very low temperatures (0 deg. cent.- 40 deg. cent.) in the vicinity of the saturation curve.

FORMULA FOR SPECIFIC HEAT

10 The application of the Clausius relation to equation [3] readily gives the following equation for the specific heat c_p:

$$c_p = \phi(T) + \frac{Amn(n+1)}{T^{n+1}} p\left(1 + \frac{ap}{2}\right) \ldots\ldots\ldots\ldots [4]$$

or

$$c_p = \phi(T) + f(p, T) \ldots\ldots\ldots\ldots [4a]$$

if the term $\frac{Amn(n+1)}{T^{n+1}} p\left(1 + \frac{ap}{2}\right)$ is replaced for convenience by $f(p, T)$. For the complete derivation of this equation see Appendix No. 2.

11 If the characteristic equation [3] is correct in form, the expression for the specific heat c_p must have the form given by [4]; and if the arbitrary function ϕ (T) can be determined, we shall have an explicit expression for c_p in terms of the variables p and T. Callendar and Linde have both used this analysis, starting from their respective characteristic equations, and have thus obtained equations similar to [4].

12 The determination of the proper form of the function ϕ (T) is the critical point of the whole investigation. If in [4], $p=0$, the equation reduces to $c_p = \phi$ (T). Callendar reasons that at zero pressure the specific heat c_p should have an invariable value $(c_p)_0$ independent of the temperature; hence $\phi(T)$ is assumed to be constant. Linde follows Callendar in this assumption. Knoblauch and Jakob, however, on the strength of their direct experiments on the values of c_p, show that $(c_p)_0$ cannot be a constant. It seems possible to establish the form of the function by quite another line of reasoning. Inspection of [4] shows that the correction term f (p, T), having the factor T^{n+1} in the denominator, grows rapidly smaller as T increases. At moderately low temperatures ($T = 100$ to 600 deg. cent.) this term has an appreciable value, but at temperatures above say 1000 deg. cent., the exponent $n+1$ being 6, the term practically disappears, and the specific heat is given by the relation

$$c_p = \phi\ (T) \ldots\ldots\ldots\ldots [5]$$

for all pressures. The determination of the function $\phi(T)$ is reduced therefore to the discovery of the relation between specific heat and temperature at high temperatures. The experiments of Mallard and Le Chatelier at temperatures above 3000 deg. cent. and the experiments of Langen at about 1700 deg. cent. agree in making the specific heat a linear function of the temperature, for the temperature range within which the experiments were made. While this linear relation may not, and probably does not, hold for the entire region of superheat, it may be assumed as a close approximation for a moderate range of temperature. The function $\phi(T)$ therefore takes the simple form

$$\phi(T) = \alpha + \beta T \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

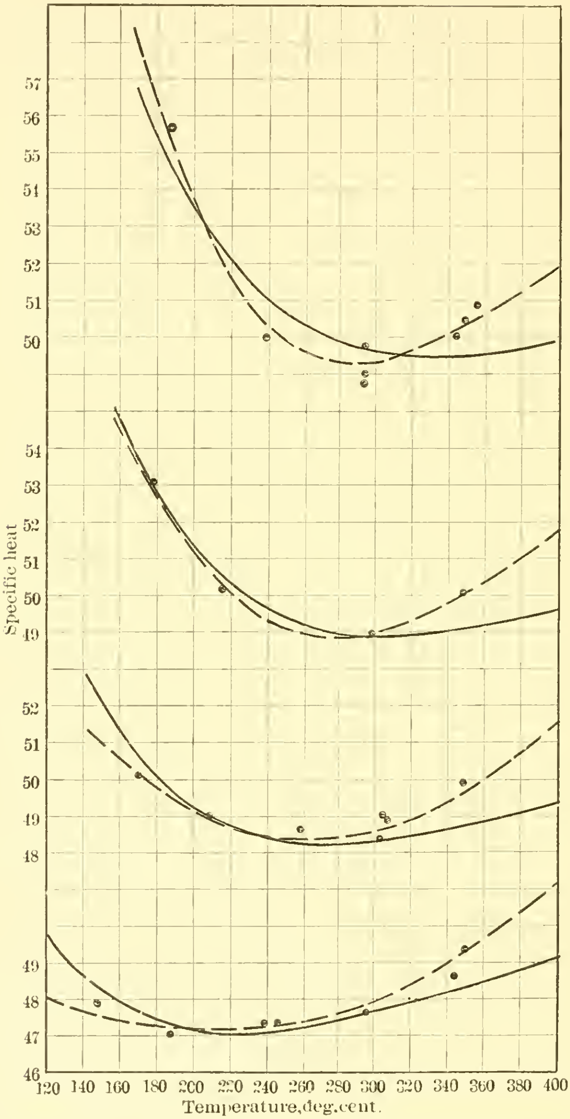

FIG. 2 COMPARISON OF SPECIFIC HEAT CURVES WITH KNOBLAUCH AND JAKOB POINTS. PRESSURES, 2, 4, 6, AND 8 KG. PER SQ. CM.

and equation [4] becomes

$$c_p = \alpha + \beta T + \frac{Amn(n+1)}{T^{n+1}} p\left(1 + \frac{ap}{2}\right) \ldots\ldots\ldots\ldots [7]$$

13 The constants a, m, and n are those heretofore given in connection with the characteristic equation [3], while in the determination of the constants α and β we may utilize the results of the various experiments of Knoblauch and Jakob, and the more recent experiments of Knoblauch and Mollier. For a fuller discussion of the values of these constants see Appendix No. 3.

14 The values finally chosen were:

$$\alpha = 0.367 \qquad \beta = 0.00018$$

Hence

$$\phi\,(T) = 0.367 + 0.00018T \ldots\ldots\ldots\ldots\ldots\ldots [8]$$

or for the fahrenheit scale

$$\left.\begin{array}{l}\phi\,(T) = 0.367 + 0.0001T \\ \phi\,(T) = 0.413 + 0.0001t\end{array}\right\} \ldots\ldots\ldots\ldots\ldots\ldots [9]$$

The agreement between the curves that represent equation [7], using the expression for $\phi\,(T)$ given by [8], and the Knoblauch and Jakob points is shown in Fig. 2. The agreement is quite satisfactory except for points in the region of 350 deg. The empirical curves adopted by Knoblauch and Jakob (shown in dash lines) were made to pass through these points and were therefore given a sharp slope above 350 deg. Furthermore, at the higher pressures the empirical curves were given much greater slopes at the intersections with the saturation curve than were shown by the curves calculated from [7]. As a result the extrapolated values of c_p at the saturation limit are suspiciously high. Marks and Davis, on the strength of results of Holborn and Henning, lowered the Knoblauch and Jakob curves in the region of high superheat, but accepted their values near saturation.

15 The experiments of Knoblauch and Mollier extend the temperature range to 550 deg. cent. The points representing these experiments are shown in Fig. 3, and the curves exhibited in the same figure represent equation [7] with the values of α and β originally chosen. For the lower pressures the agreement between points and curves is satisfactory. At the higher pressures the agreement could be slightly improved by raising the value of α from 0.367 to 0.369 or 0.370. For further discussion of the validity of equation [7] and values chosen for the constants α and β see Appendix No. 6.

HEAT CONTENT, ENERGY AND ENTROPY

16 With the aid of an explicit formula for the specific heat, the following expressions for the heat content, energy and entropy of superheated steam are readily derived:

For heat content:

$$i=aT+\tfrac{1}{2}\beta T^2-\frac{Am(n+1)}{T^n}p\left(1+\frac{ap}{2}\right)-Acp+i_o \ldots\ldots\ldots [10]$$

For intrinsic energy (in b.t.u.):

$$u=T(a+\tfrac{1}{2}\beta T-AB)-\frac{Amp}{T^n}\left[n+(n-1)\frac{ap}{2}\right]+i_o \ldots\ldots\ldots [11]$$

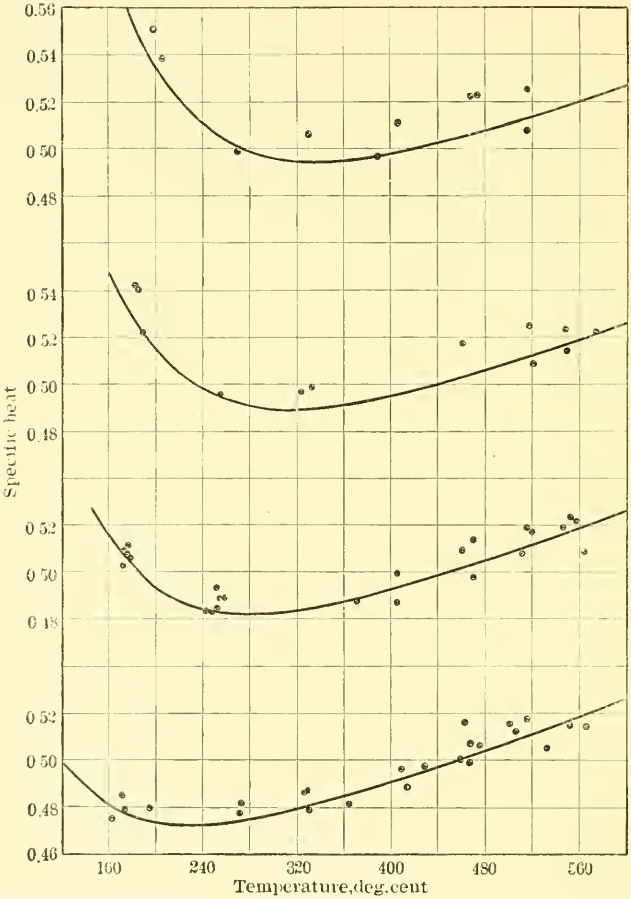

FIG. 3 COMPARISON OF SPECIFIC HEAT CURVES WITH KNOBLAUCH AND MOLLIER POINTS. PRESSURES, 2, 4, 6, AND 8 KG. PER SQ. CM.

For entropy:

$$s=a\log_e T+\beta T-AB\log_e p-Anp\left(1+\frac{ap}{2}\right)\frac{m}{T^{n+1}}+s_o \ldots\ldots [12]$$

For the derivation of these equations see Appendix No. 4.

17 Formula [10] gives the heat content i of superheated steam at any assumed pressure p and temperature T. Since the formula should hold good at the saturation limit, it also gives the value of i for saturated steam when corresponding saturation values of p and T are used. A comparison of the saturation values of i thus obtained with the values given by Marks and Davis will furnish a test of the accuracy of equation [10], and incidentally a test of the entire theory built up from equations [3] and [7]. Taking 1150.4 b.t.u. as the value of i for saturated steam at 212 deg. (the value given by Marks and Davis), the constant i_o is found to be 887.3; and using this value of i_o, the values of i shown in Table 1 are obtained. For a further discussion of the agreement between the two sets of values, and in particular for a proposed modification of Dr. Davis' formula for the heat content see Appendix No. 5.

TABLE 1 VALUES OF i AT SATURATION

Temperature, Deg. Fahr.	Calculated from [10] $i_o = 887.3$	Marks and Davis	Difference, Per Cent
32	1079.6	1073.4	0.58
50	1087.0	1081.4	0.52
75	1097.3	1092.5	0.44
100	1107.4	1103.6	0.34
125	1117.4	1114.5	0.26
150	1127.2	1125.3	0.17
200	1146.0	1145.8	0.02
212	1150.4	1150.4	0.00
250	1163.5	1163.8	−0.03
300	1179.5	1179.1	+0.04
350	1193.6	1191.5	0.18
400	1205.7	1201.3	0.35
450	1215.3	1208.0	0.61

18 From the comparison of the two sets of values in Table 1, and from the considerations set forth in Appendix No. 5, the following conclusions may be drawn:

(*a*) Equation [10] gives with fair accuracy the saturation values of the heat content from 120 deg. to 450 deg. fahr., that is, from a pressure of 1.7 lb. per sq. in. to 420 lb. per sq. in.

(*b*) Equation [10] therefore probably gives quite accurately the heat content of superheated steam for this pressure range and for the degree of superheat usually employed in technical applications.

(*c*) The validity of equation [10] carries with it the validity of the analysis, and justifies the choice of constants in equations [3] and [7].

(*d*) For extremely low pressures the exact values of the various properties of steam are still in doubt, and further investigation is required.

RESUMÉ OF FORMULAE

19 The formulae for the important properties of superheated steam, with the numerical values of the constants inserted, are here collected for convenience of reference. In all cases the constants are so chosen that pressures are to be taken in pounds per square inch.

(*a*) For the specific volume:

$$v=0.5963\frac{T}{p}-(1+0.0006p)\frac{C}{T^5}-0.088$$

$$\log C=13.67938$$

(*b*) For the specific heat:

$$c_p=0.367+0.0001T+p(1+0.0003p)\frac{C_2}{T^6}$$

$$\log C_2=14.42408$$

(*c*) For the heat content:

$$i=T(0.367+0.00005T)-p(1+0.0003p)\frac{C_3}{T^5}-0.0163p+887.3$$

$$\log C_3=13.72511$$

(*d*) For the intrinsic energy in b.t.u.:

$$u=T(0.2566+0.00005T)-p(1+0.00024p)\frac{C_4}{T^5}+887.3$$

$$\log C_4=13.64593$$

(*e*) For the entropy:

$$s=0.8451\log T+0.0001T-0.2542\log p-p(1+0.0003p)\frac{C_5}{T^6}-0.3960$$

$$\log C_5=13.64593$$

COMPARISON OF RESULTS

20 From the formulae in Par. 19 the properties of superheated steam may be calculated for assumed values of p and T. It may be of interest to compare the values thus obtained with the values given in the Marks and Davis table. Such a comparison is shown in Table 2. Various pressures from 2 to 300 lb. per sq. in. are assumed and the superheat ranges from 0 deg. to 400 deg. fahr.

TABLE 2 COMPARISON OF THE CALCULATED VALUES OF THE PROPERTIES OF SUPERHEATED STEAM WITH THE VALUES GIVEN IN THE MARKS AND DAVIS TABLE

	Pressure, Lb. per Sq. In.														
	2		15		50		100		150		200		300		Superheat, Deg.
	Cal.	(M and D)	Cal.	(M and D)	Cal.	(M and D)	Cal	(M and D)	Cal.	(M and D)	Cal.	(M and D)	Cal.	(M and D)	
			26.32												
Volume, v	174.0	173.5	26.32	26.27	8.52	8.51	4.44	4.43	3.02	3.01	2.30	2.29	1.55	1.55	0
	189.1	189.2	28.41	28.40	9.18	9.19	4.79	4.79	3.26	3.27	2.48	2.49	1.67	1.69	50
	204.2	204.2	30.47	30.46	9.83	9.84	5.12	5.14	3.49	3.51	2.65	2.68	1.79	1.83	100
	234.2	234.2	34.53	34.53	11.07	11.11	5.75	5.80	3.92	3.97	2.98	3.04	2.01	2.09	200
	294.0	293.9	42.55	42.59	13.51	13.58	6.98	7.07	4.74	4.83	3.60	3.71	2.43	2.55	400
Heat Content, i	1117.8	1115.0	1150.7	1150.7	1173.6	1173.6	1187.6	1186.3	1195.9	1193.4	1201.6	1198.1	1209.3	1204.1	0
	1139.8	1137.8	1174.3	1174.2	1199.2	1198.8	1214.8	1213.8	1224.2	1223.0	1231.0	1229.8	1240.2	1240.3	50
	1161.7	1160.7	1197.3	1197.6	1223.9	1223.4	1240.8	1239.7	1251.2	1249.6	1258.7	1257.1	1269.2	1268.2	100
	1206.1	1206.4	1243.8	1244.4	1272.3	1271.8	1291.0	1289.4	1302.7	1300.0	1317.3	1307.7	1323.7	1319.3	200
	1297.5	1298.6	1337.7	1338.3	1368.7	1367.4	1389.6	1385.9	1403.0	1397.4	1412.9	1405.9	1427.6	1418.6	400
Entropy, s	1.9231	1.9180	1.7549	1.7549	1.6578	1.6581	1.6028	1.6020	1.5710	1.5692	1.5490	1.5456	1.5175	1.5129	0
	1.9587	1.9559	1.7887	1.7886	1.6911	1.6909	1.6363	1.6358	1.6049	1.6043	1.5828	1.5823	1.5518	1.5530	50
	1.9921	1.9904	1.8199	1.8199	1.7214	1.7211	1.6665	1.6658	1.6350	1.6343	1.6130	1.6120	1.5822	1.5824	100
	2.0526	2.0529	1.8761	1.8768	1.7759	1.7755	1.7201	1.7188	1.6884	1.6862	1.6662	1.6632	1.6354	1.6323	200
	2.1561	2.1586	1.9730	1.9733	1.8688	1.8671	1.8111	1.8079	1.7781	1.7735	1.7555	1.7493	1.7238	1.7168	400

21 It will be seen that there is substantial agreement between the values for the heat content i and also between the values for the entropy s. The maximum difference between the values of i is slightly over 0.6 of one per cent and that between the values of s is about 0.4 of one per cent. The discrepancy between the values of v is somewhat larger at the higher superheats. From Linde's own statement of the defect in his formula when applied at high temperatures, it appears probable that the values obtained from formula [3] are more accurate than those calculated from Linde's formula. It is remarkable that the values of i and s obtained from quite different specific heat curves should agree so well. And it is gratifying that the accuracy of the Marks and Davis tables is confirmed by this close agreement.

22 Acknowledgment is due Mr. A. L. Schaller and Mr. John A. Dent for assistance in the calculations and for valuable suggestions.

APPENDIX No. 1

VALIDITY OF EQUATIONS [2] AND [3] AT THE SATURATION LIMIT

$$pv = BT - p(1 + ap)\left[C\left(\frac{373}{T}\right)^3 - D\right]$$

$$p(v + c) = BT - p(1 + ap)\frac{m}{T^n}$$

23 Equations [2] and [3] may also be tested by calculating from them values of v at the saturation limit and comparing these with values determined experimentally or with values calculated from the properties of saturated steam by means of the well known Clapeyron-Clausius formula. Table 3 gives a series of values thus determined.

TABLE 3 SPECIFIC VOLUME v AT SATURATION

Temperature, Deg. Cent.	Experiments of K. L. and K.	Calculated from [2]	Calculated from [3]	Calculated by Henning
100	1.674	1.674	1.673	1.673
120	0.8922	0.8915	0.8915	0.8912
140	0.5091	0.5083	0.5084	0.5078
160	0.3073	0.3070	0.3071	0.3071
180	0.1943	0.1943	0.1945	0.1947

24 The values given in the last column are of special significance. They are those calculated by Henning, using as a basis his recently determined values of the latent heat and Holborn and Henning's accurate values of $\frac{dp}{dt}$. That these values agree so closely with the values determined by the direct experiments of Knoblauch, Linde and Klebe is convincing evidence of the accuracy attained in both sets of experiments. It will be observed that the values of v_{sat} given by [3] agree substantially with both sets of values; hence it appears that equation [3] may be accepted with confidence at the saturation limit.

APPENDIX No. 2

DERIVATION OF EQUATION [4]

$$c_p = \phi(T) + \frac{Amn(n+1)}{T^{n+1}} p\left(1 + \frac{ap}{2}\right)$$

25 Writing the characteristic equation [3] in the form

$$v + c = \frac{BT}{p} - (1 + ap)\frac{m}{T^n}$$

the following derivatives are readily obtained:

$$\frac{\partial v}{\partial T} = \frac{B}{p} + \frac{mn}{T^{n+1}}(1 + ap) \qquad \text{[13]}$$

$$\frac{\partial^2 v}{\partial T^2} = -\frac{mn(n+1)}{T^{n+2}}(1 + ap) \qquad \text{[14]}$$

Substituting the second derivative in the Clausius equation

$$\left[\frac{\partial c_p}{\partial p}\right]_T = -AT\frac{\partial^2 v}{\partial T^2}$$

the result is the relation

$$\left[\frac{\partial c_p}{\partial p}\right]_T = \frac{Amn(n+1)}{T^{n+1}}(1 + ap) \qquad \text{[15]}$$

Taking T as a constant and integrating [15] with p as the independent variable, the result is

$$c_p = \frac{Amn(n+1)}{T^{n+1}} p(1 + \frac{ap}{2}) + \text{constant of integration}$$

The constant of integration may be a function of T, since T was held constant during the integration; hence

$$c_p = \phi(T) + \frac{Amn(n+1)}{T^{n+1}} p(1 + \frac{ap}{2}) \qquad \text{[16]}$$

APPENDIX No. 3

CONSTANTS α AND β IN EQUATIONS [6] AND [7]

$$\phi(T)=\alpha+\beta T$$

$$c_p=\alpha+\beta T+\frac{Amn(n+1)}{T^{n+1}}p\left(1+\frac{ap}{2}\right)$$

26 The limits of the value of β are furnished by the linear equations deduced from the explosion experiments and from the experiments of Holborn and Henning. Thus the results of the experiments of Mallard and Le Chatelier at a temperature above 3000 deg. are represented by the equation

$$c_p=0.432+0.000318T$$

Langen's experiments at about 1700 deg. cent. are represented by the equation

$$c_p=0.438+0.000239T$$

and the experiment of Holborn and Henning for temperature below 800 deg. cent. by the equation

$$c_p=0.446+0.0000956T$$

There is reason to believe that the values given by Holborn and Henning are too low. It appears that the coefficient of T is not constant but increases with the temperature; and the value chosen for β will be influenced by the temperature range over which the formula for c_p is assumed to extend. Since in technical applications the temperatures encountered are relatively low, β should probably be smaller than Langen's value 0.000239, and bearing in mind the probable error in the results of Holborn and Henning, β should be considerably higher than the value 0.0000956.

27 In the original determination of the constants α and β, the results of the experiments of Knoblauch and Jakob were used. The later experiments of Knoblauch and Mollier had not been published. The "correction term" $f(p, T)$ of equation [7] was calculated for assumed temperatures and for the pressures 2, 4, 6 and 8 kg. per sq. cm. employed by Knoblauch and Jakob. Then by trial, values of α and β were so chosen as to make the specific heat curves

$$c_p=\alpha+\beta T+f(p, T)$$

fit as closely as possible the experimental points.

APPENDIX No. 4

DERIVATION OF EQUATIONS [10], [11] AND [12]

$$i = \alpha T - \tfrac{1}{2}\beta T^2 - \frac{Am(n+1)}{T^n} p\left(1 + \frac{ap}{2}\right) - Acp + i_0$$

$$u = T(\alpha + \tfrac{1}{2}\beta T - AB) - \frac{Amp}{T^n}\left[n + (n-1)\frac{ap}{2}\right] + i_0$$

$$s = \alpha \log_e T + \beta T - AB \log_e p - Anp\left(1 + \frac{ap}{2}\right)\frac{m}{T^{n+1}} + s_0$$

28 With the aid of an explicit formula for the specific heat, expressions for the heat content, energy, and entropy of superheated steam are as easily derived. For this purpose the general equation

$$dq = c_p dT - AT\left(\frac{\partial v}{\partial T}\right)_p dp \dots\dots\dots\dots [17]$$

is most convenient. Since the heat content i is defined by the relation

$$i = A(u + pv)$$

we have

$$di = c_p dT - A\left(\frac{\partial v}{\partial T} - v\right)dp \dots\dots\dots\dots [18]$$

From the characteristic equation [3] the derivative $\frac{\partial v}{\partial T}$ is found to be

$$\frac{\partial v}{\partial T} = \frac{B}{p} + \frac{mn}{T^{n+1}}(1 + ap)$$

Substituting this and also the expression for c_p in [18], the result is

$$di = (\alpha + \beta T)dT + Amn(n+1)p\left(1 + \frac{ap}{2}\right)\frac{dT}{T^{n+1}} - \frac{Am(n+1)}{T^n}(1 + ap)dp - Acdp$$

The integral of this exact differential is readily found to be

$$i = \alpha T + \frac{1}{2}\beta T^2 - \frac{Am(n+1)}{T^n} p\left(1 + \frac{a}{2}p\right) - Acp + i_0 \dots\dots\dots\dots [19]$$

29 The equation for intrinsic energy is derived from the relation

$$Au = i - Apv$$

Substituting for i the expression given by [10], we obtain for the energy expressed in b.t.u.

$$u = T\left(\alpha + \frac{1}{2}\beta T - AB\right) - \frac{Amp}{T^n}\left[n + (n-1)\frac{a}{2}p\right] + i_0 \dots\dots\dots\dots [20]$$

30 For the entropy an expression is readily found from [17]. Thus

$$ds=\frac{dq}{T}=c_p\frac{dT}{T}-A\frac{\partial v}{\partial T}pdp$$

Introducing in this equation the expressions previously derived for c_p and $\frac{\partial v}{\partial T}$, the result is

$$ds=\left(\frac{\alpha}{T}+\beta\right)dT+Amn(n+1)p\left(1+\frac{a}{2}p\right)\frac{dT}{T^{n+2}}-AB\frac{dp}{p}-\frac{Amn}{T^{n+1}}(1+ap)dp$$

The integral is

$$s=\alpha\log_e T+\beta T-AB\log_e p-Anp\left(1+\frac{a}{2}p\right)\frac{m}{T^{n+1}}+s_0 \quad\ldots\ldots\ldots[21]$$

31 The constants of integration i_0 and s_0 may be obtained by passing to the saturation limit. Thus let [10] be written

$$i=i'+i_0$$

where i' stands for the variable part of the second member. The constants α, β, m, n, and a being known, i' can be found for any assumed pressure and temperature. Let i' be calculated for a given temperature T_1 and the corresponding *saturation* pressure p_1; from the properties of saturated steam i is known for this same state, and i_0 is at once determined by subtraction. In the same way the constant s_0 may be determined.

APPENDIX No. 5

THE SATURATION VALUES OF i FROM FORMULA [10] COMPARED WITH THE VALUES GIVEN BY MARKS AND DAVIS, AND A PROPOSED MODIFICATION OF THE DAVIS FORMULA FOR THE HEAT CONTENT

32 For an intermediate range of temperature 200 deg. to 300 deg. (see Table 1) the agreement between the two sets of values is all that could be desired. Even for the range 100 deg. to 400 deg. the discrepancy only slightly exceeds $\frac{1}{3}$ of one per cent. Below 100 deg. and above 400 deg., however, the discrepancy becomes relatively large. It is possible to distribute the difference between the ends and the middle of the temperature range; thus if i_o be taken as 884.2 formula [19] gives values at 32 deg. and 450 deg., about 0.35 per cent larger and at 212 deg. about 0.3 per cent smaller than the corresponding values of Marks and Davis. If these latter values are accepted as final, the agreement of the two sets of values for the range 32 deg. to 450 deg. with a maximum deviation of $\frac{1}{3}$ of one per cent might be taken as evidence of the validity of equation [10]. However, before passing final judgment it will be instructive to examine somewhat in detail the experimental data relative to the heat content of superheated steam.

33 In Fig. 4, which is substantially a reproduction of part of Fig. 5 in the paper of Dr. Davis, the curve represents the values of i calculated from formula [10], with $i_o = 887.3$. For convenience the C scale of temperature is used, and the range is from 60 deg. to 190 deg. cent. The ordinates are the values of $i - i_{100}$ calories and the points are located from the data contained in Tables 1 and 2 of the paper in question. The points indicated by the symbol • represent the measurements of Henning; the other points are those deduced by Dr. Davis from the throttling experiments of Grindley, Griessmann and Peake. In Fig. 5 the curve shows values of i in b.t.u. calculated from equation [10] and the points represent values of i deduced from experiments on the latent heat r by Dieterici, Griffiths, Smith and Henning. The range 32 to 212 deg. fahr. is covered.

34 Directing attention to Fig. 4, it is seen that the points representing Henning's experiments accord well with the points deduced from the throttling experiments with the exception of the points at 140 deg. and 180 deg. Dr. Davis asserts that the point at 180 deg. is not entitled to nearly so much weight as the others because of a defect in the experimental apparatus. Probably this assertion is well founded. On the other hand, the points deduced from the throttling experiments in the region of 180 deg. are perhaps slightly low. In deriving the values from which these points are located, Dr. Davis used the specific heat measurements of Knoblauch and Jakob. Near the saturation limit these values of c_p are undoubtedly too high at the higher pressures. The result of using lower values of c_p is to raise the points in question. The change, however, is slight and is not sufficient to bring the points upon the curve.

35 An examination of the derivative $\frac{di}{dt}$ along the saturation curve may afford another basis of comparison. From the second degree equation of Dr. Davis, namely,

$$i=1150.4+0.3745(t-212)+0.00055(t-212)^2$$

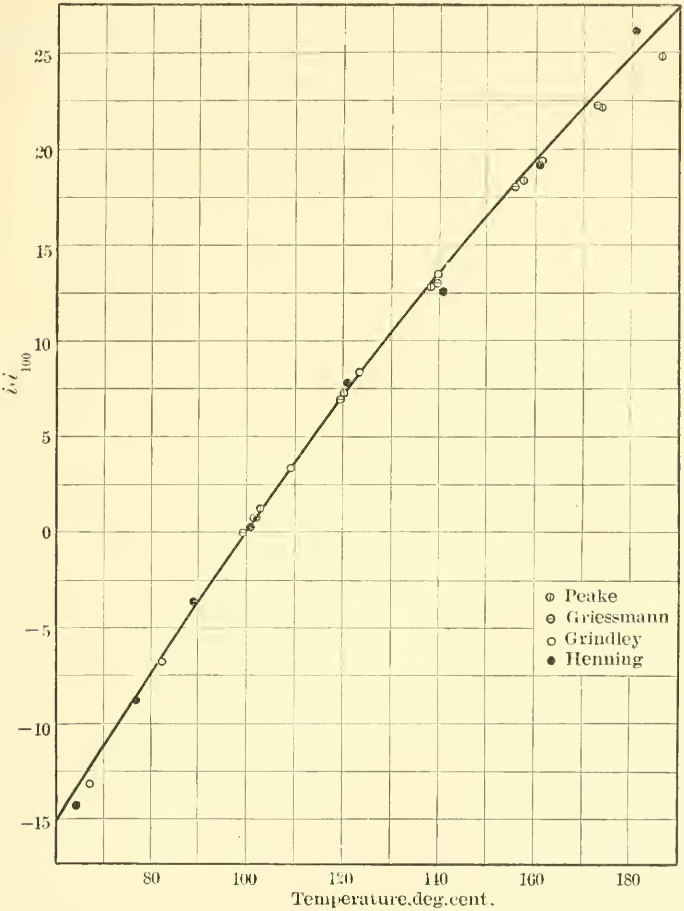

FIG. 4 CURVE REPRESENTING VALUES OF $i-i_{100}$ CALCULATED FROM [10]. THE POINTS GIVE VALUES DETERMINED FROM THE EXPERIMENTS OF HENNING, GRINDLEY, GRIESSMANN AND PEAKE

we have

$$\frac{di}{dt}=0.3745-0.0011(t-212)$$

This linear relation is shown by the straight line A, Fig. 6. Writing [19] in the form $i=(p, T)$, we obtain

$$\left[\frac{di}{dt}\right]_{sat}=\left[\frac{di}{dT}\right]_p+\left[\frac{\partial i}{\partial p}\right]_T\left[\frac{dp}{dt}\right]_{sat}=c_p+\left[\frac{\partial i}{\partial p}\right]_T\frac{dp}{dt} \quad \ldots\ldots\ldots\ldots [22]$$

From [19] an expression for the derivative $\left[\frac{\partial i}{\partial p}\right]_{\mathrm{T}}$ is readily found, and the final result is

$$\left[\frac{di}{dt}\right]_{\mathrm{sat}}=c_{\mathrm{p}}-\frac{dp}{dt}\left[\frac{Am(n+1)}{T^{\mathrm{n}}}(1+ap)+c\right] \ldots\ldots\ldots\ldots\ldots [23]$$

The values of this derivative for different temperatures ranging from 200 deg. to 425 deg. fahr. are shown by curve B, Fig. 6. The horizontal straight line C represents the Regnault value $\frac{di}{dt}=0.305$. The form of [23] is such that the relation between $\frac{di}{dt}$ and t cannot be represented by a straight line. Repeated attempts were made to change the constants α, β, m, n and a in such a way as to straighten curve B and at the same time preserve the integrity of equations [3] and [7]. Such attempts were futile. The result of changing one constant would be neutralized by the necessary change in another, and the position of curve B would remain substantially unchanged. It follows that this curve must be accepted along with the characteristic equation [3] and the specific heat equation [7], or all three must be rejected. Curve B between the temperature limits shown may be approximately represented by a second degree equation though a third degree equation gives a closer agreement. Hence an approximate algebraic equation for i of the form $i=f(t)$ must be of the third degree at least.

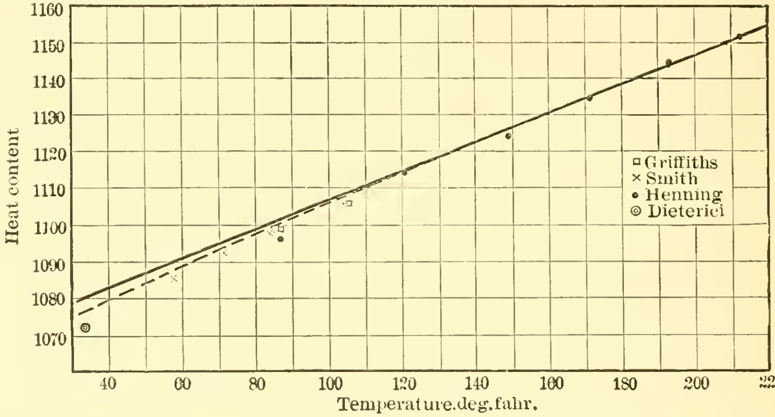

FIG. 5 CURVE REPRESENTING VALUES OF i IN B.T.U. CALCULATED FROM [10]. THE POINTS REPRESENT THE RESULTS OF VARIOUS EXPERIMENTS

36 The formula of Dr. Davis has been so universally accepted that a suggestion that it should be modified may seem presumptuous. The three points brought out in Pars. 33 to 35, however, lead to these conclusions: (*a*) The evidence furnished by Henning's point at 180 deg., whatever value may be attached to it, indicates that the Davis curve should be raised near 180 deg. (*b*) The newer and probably more accurate values of c_{p} near saturation if used in determining the points deduced from the throttling experiments would raise these points near 180 deg. (*c*) Any equation of the form $i=f(p, T)$ deduced from a characteristic equation and an equation $c_{\mathrm{p}}=\phi(p, T)$, as [10] was deduced,

cannot have a derivative $\left[\frac{di}{dt}\right]_{\text{sat}}$ which is a linear function of the temperature. It is perhaps too much to assert that equation [10] is more accurate than the Davis formula for temperatures above 212 deg., but it is clear that the discrepancy between the values of i in Table 1, for the higher temperature, may be due in part to errors in the Marks and Davis values of i; it therefore furnishes no adequate basis for a rejection of the analysis leading to equation [10].

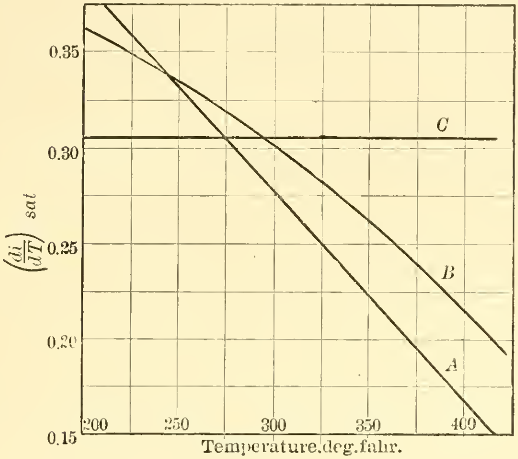

Fig. 6 Curves for $\left(\frac{di}{dT}\right)_{\text{sat}} = f(t)$

A from the Davis Equation; *B* from [19]; *C* from Regnault's Equation

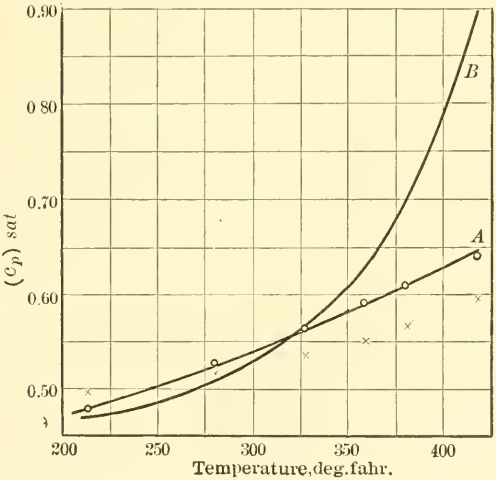

Fig. 7 Curves showing Variation of $(c_p)_{\text{sat}}$ with the Temperature

37 For temperature below 212 deg. it is seen by reference to Fig. 5 that the curve derived from [19] fits very closely Henning's points from 120 deg. to 212 deg. Below 120 deg. the curve lies somewhat above the points determined by Dieterici, Griffiths, and Smith. It is probable, therefore, that for temperatures below 120 deg. equations [7] and [10] require modification. It may be pointed out that throughout the entire range, equation [10] represents the experiments of Henning about as well as any single empirical formula that could be produced.

38 Equation [21] gives the entropy of superheated steam for assumed values of p and T and may therefore be used to obtain the entropy of saturated steam. It will be of interest to compare the values thus determined with the values obtained in the usual way from the properties of saturated steam. This comparison is shown in Table 4. In the second column are given values from the Marks and Davis table; in the third column values obtained by using in the term

TABLE 4 ENTROPY OF SATURATED STEAM

Temperature, Deg. Fahr.	Entropy at Saturation		
	Marks and Davis	Marks and Davis with Modified Values of r	Calculated from [21]
100	1.9800	1.9869	1.9856
150	1.8674	1.8706	1.8706
200	1.7761	1.7765	1.7766
212	1.7565	1.7565	1.7565
250	1.6996	1.6992	1.6990
300	1.6343	1.6346	1.6342
350	1.5780	1.5800	1.5793
400	1.5286	1.5327	1.5322
450	1.4850	1.4911	1.4911

$\frac{r}{T}$, values of r derived from [10], and in the fourth column values calculated directly from [21]. The constant s_0 is found to be -0.3960.

The agreement between the corresponding values in the last two columns scarcely requires comment.

APPENDIX No. 6

VALIDITY OF EQUATION [7] AND VALUES OF CONSTANTS α AND β; ALSO FURTHER TESTS OF THE EQUATION FOR SPECIFIC HEAT

39 The evidence furnished by the Knoblauch and Mollier experiments is clearly in favor of the validity of formula [7] and justifies the values chosen for the constants α and β. The slope of the c_p curves at high temperature is evidently much smaller than was assumed in the original empirical curves of Knoblauch and Jakob and, for the temperature range under consideration, appears to be given correctly by the assumed value of β, namely $\beta = 0.00018$. There is still to be accounted for a considerable discrepancy between the slope thus determined and the slope of the Holborn and Henning curve. Holborn and Henning really determined, not the specific heat of steam directly, but the ratio of this specific heat to the specific heat of air under the same conditions. Comparing the results of Holborn and Henning on the specific heat of air with the results obtained by Joly and Swann, Callendar[1] makes the following statement: "The value found for the mean specific heat of air over the range 115 deg. to 270 deg. cent. by Holborn and Henning was 0.2315, which is about 5 per cent smaller than the probable value over this range. . . . . If the method gives a probable error of 5 per cent over the range 115 deg. to 270 deg., it does not seem at all impossible that the error may amount to 10 per cent over the range 115 deg. to 1400 deg. cent." Callendar's argument seems reasonable, and it is a fair conclusion that the experiments of Knoblauch and Mollier should be accepted as more worthy of confidence than the experiments of Holborn and Henning.

40 Formula [7] may be subjected to several other tests, namely: (*a*) The saturation values of c_p may be checked by Planck's thermodynamic relation; (*b*) the spacing of the c_p curves for different pressures may be tested by a method which connects c_p with the Joule-Thomson coefficient μ. This method is due to Dr. Davis.[2] (*c*) A relation between c_p, μ, and the heat content i of saturated steam affords a check on the values of c_p near the saturation limit at very low temperatures.

41 The values of c_p at saturation may be tested by Planck's equation

$$(c_p)_{\text{sat}} = \frac{dH}{dt} - \frac{r}{T} + AT\frac{dp}{dt}\left(\frac{\partial v}{\partial T}\right)_p \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [24]$$

This equation was used effectively by Dr. Davis in showing that Knoblauch's values are preferable to those given by Thomas. It will be observed that with the exception of the derivative $\left[\frac{\partial v}{\partial T}\right]_p$, which may be obtained from [3], the terms in [22] are obtained from the properties of saturated steam. The total heat H and heat content i_{sat} of saturated steam are connected by the relation

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[1] Appendix to the Report of the British Association Committee on the Investigation of Gaseous Explosions, Clerk's Gas, Petrol, and Oil Engines, pp. 361–367.

[2] Proc. Amer. Acad., vol. 45, p. 290.

$$H = i_{sat} - Apv'$$

in which v' denotes the specific volume of water; hence the derivative $\frac{dH}{dT}$ is found from the relation

$$\frac{dH}{dT} = \left[\frac{di}{dt}\right]_{sat} - Av'\frac{dp}{dt} \qquad \text{[25]}$$

In the calculation of the values in Table 5 two courses were followed: (*a*) the derivative $\left[\frac{di}{dt}\right]_{sat}$ was found from the Davis equation

$$i = 1150.4 + 0.3745(T - 212) - 0.00055(T - 212)^2$$

TABLE 5 VALUES OF c_p AT SATURATION

Pressure, Lb. per Sq. In.	Calculated from [22]		Calculated from [7]	Knoblauch and Jakob Curves
	Using Values from Marks and Davis	Using Values from [19]		
15	0.4970	0.4796	0.4775	0.472
50	0.5071	0.5241	0.5228	0.508
100	0.5343	0.5661	0.5604	0.565
150	0.5503	0.5903	0.5876	0.630
200	0.5677	0.6106	0.6097	0.705
300	0.5973	0.6410	0.6454	0.898

and values of $\frac{r}{T}$ were taken directly from the Marks and Davis tables; (*b*) the derivative was found from [10] (see [23], Appendix No. 6) and values of the latent heat r were obtained by subtracting from i_{sat} calculated from [10] the heat content of the liquid given in the Marks and Davis table. Table 5 shows the results of the calculation.

42 In Fig. 7, curve A represents the values of $(c_p)_{sat}$ calculated from [7] and curve B the values given by Knoblauch and Jakob. The points near curve A represent the values in column 3 of Table 5 and the points indicated by crosses represent the values in column 2. The agreement between curve A and the first set of points is sufficiently close to afford a confirmation of equation [7] at the saturation limit. For temperatures above 350 deg. curve B is clearly inadmissible. While the values of $(c_p)_{sat}$ obtained from Planck's equation [24] are in doubt, depending as they do on values of i and r that are not precisely known, it is impossible to bring the points calculated from [24] in harmony with curve B. For temperature above 212 deg., at least, equation [7] satisfies the test furnished by Planck's relation.

43 The specific heat curves derived from equation [7] may be tested by a method developed by Dr. Davis in the paper heretofore cited. It is based upon the following relation between c_p and the Joule-Thompson coefficient

$$c_p = (c_p)_0 e^{-\int_{p_0}^{p}\left(\frac{\partial\mu}{\partial t}\right)_p dp} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [26]$$

By means of this relation the ratio $\frac{c_p}{(c_p)_0}$ may be calculated for assumed values of p and T along a curve of constant heat content i. The specific heat $(c_p)_0$ is taken at an assumed standard pressure, which was assumed by Dr. Davis as 1 kg. per sq. cm. Evidently the method gives only relative results; that is, it does not give the absolute position of any c_p curve, but rather the spacing of the family of c_p curves. Using the data given by Dr. Davis in Table 5 of his paper, the various ratios $\frac{c_p}{(c_p)_0}$ were calculated from equation [7] and the results obtained were compared with the results derived from the calculations of Dr. Davis. Table 6 shows the two sets of values.

TABLE 6 COMPARISON OF c_p RATIOS

Pressure, Kg. per Sq. Cm.	Curve 1			Curve 2			Curve 3			Curve 4		
	Temperature, Deg. Cent.	$\frac{c_p}{(c_p)_0}$		Temperature, Deg. Cent.	$\frac{c_p}{(c_p)_0}$		Temperature, Deg. Cent.	$\frac{c_p}{(c_p)_0}$		Temperature, Deg. Cent.	$\frac{c_p}{(c_p)_0}$	
		Davis	From [7]		Davis	From [7]		Davis	From [7]		Davis	From [7]
0.1	121.3	0.946	0.945	149.0	0.960	0.962	204.5	0.984	0.981	287 8	0.994	0.993
0.5	121.3	0 970	0.970	150.5	0.979	0.979	205.4	0.991	0.990			
1.0	125.8	1.000	1.000	152.3	1.000	1.000	206.4	1.000	1.000	288.9	1.000	1.000
2.0	130.6	1.060	1.053	155.8	1.041	1.035	208.5	1.018	1.020	290.1	1.007	1.006
3.0	135.1	1.120	1.10	159.1	1.082	1.081	210.5	1.034	1.039			
3.5	137.2	1.150	1.122									
6.0				162.3	1.122	1.107	212.5	1.051	1.057	292.4	1.020	1.023
6.0				168.5	1.200	1.165	216.5	1.084	1.091	294.7	1.032	1.038
8.0				174.3	1.264	1.215	220.2	1.118	1.123	297.0	1.044	1.052
10.0				179.7	1.344	1.260	223.9	1.151	1.151	299.2	1.057	1.066

An inspection of Table 6 shows close agreement at the lower pressures and some divergence at the higher pressures. This test, while of value in a general way, must be taken with some reservation. In the first place the value of the coefficient μ is not known with absolute accuracy. Secondly the constant i curve that must be laid down before the calculation is started depends upon the assumed saturation values of i. If i_{sat} is determined from [10] instead of from the Davis formula, the constant i curves will lie nearer the saturation curve and as a result the values of $\frac{c_p}{(c_p)_0}$ calculated from equation [7] will be larger at the higher pressures.

44 A test that applies at low temperatures near the saturation limit is furnished by Griessman's equation

$$c_p = \frac{\frac{\delta i}{\delta T}}{1 - \mu \frac{dp}{dT}}$$

in which μ denotes the Joule-Thomson coefficient. This relation is in reality identical with that given by equation [22] and may be derived from [22] with the aid of the defining relation $\mu = \left[\frac{\partial T}{\partial p}\right]_i$. Since μ and c_p are intrinsically positive, Griessman's equation imposes the condition that at the saturation limit c_p must be numerically greater than the derivative $\left[\frac{di}{dT}\right]_{\text{sat}}$. On page 290 of his paper

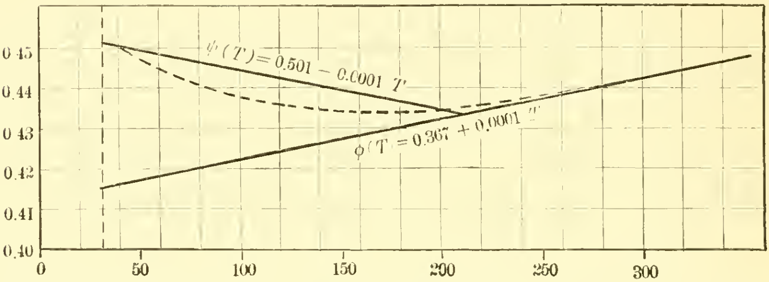

FIG. 8 CURVES REPRESENTING POSSIBLE FORMS OF THE FUNCTION ψ (T) NEAR 32 DEG. FAHR.

Dr. Davis concludes from this condition that at 32 deg. fahr. $(c_p)_{\text{sat}}$ must be as great as 0.44. From [7] the values of $(c_p)_{\text{sat}}$ is about 0.417. A consideration of this discrepancy throws light on the question heretofore raised relative to heat content at the lower temperatures. The minimum value 0.44 assigned by Mr. Davis is evidently derived from the value of the derivative $\left[\frac{di}{dT}\right]_{\text{sat}}$ at 32 deg.; that is, it is the slope of the curve giving the saturation values of i (see Fig. 5) at 32 deg. As the values of i near 32 deg. are very uncertain, no great weight can be attached to this particular number 0.44. From the connection between the equations [7] and [10], Griessman's relation is automatically satisfied at all temperatures by values of c_p calculated from [7] and values of i calculated from [10]; hence at 32 deg. the slope of the curve $i_{\text{sat}} = f(T)$, Fig. 5, must be less than 0.417. If, however, the curve were lowered to agree more closely with the experimental points the slope at 32 deg. would be increased, and as a result c_p would be raised. By an arbitrary change in the function $\phi(T)$ within the range of 32 deg. to 212 deg. the curve of Fig. 5 may be wrenched into closer agreement with the points and $(c_p)_{sat}$ at 32 deg. may be correspondingly raised. In [7] ψ (T) was taken as $0.367+0.0001T$. Let this be replaced by the function $\psi(T)=0.501-0.0001T$; then in [10] the first two terms for the expression for i become

$$\int \psi(T)dT=0.501T-0.00005T^2+C$$

The straight lines representing $\phi(T)$ and $\psi(T)$ (see Fig. 8) intersect at $t=210$ deg. $(T=670)$; hence the constant C is determined by the condition that the value of i for $T=210$ deg. shall be the same when calculated by the modified equation as when obtained from [10]. The effect of this modification of formula [10] is shown by the dash curve, Fig. 5. The resulting value of $(c_p)_{sat}$ at 32 deg. is 0.452, which is very nearly the value taken by Marks and Davis.

45 The process just described is wholly artificial and cannot be justified on any rational basis. There is no reason to suppose that the function $\phi(T)$ is properly represented by a broken line, as shown in Fig. 8. It is conceivable that for the range of temperature under consideration the function should be represented by a curve somewhat of the form shown in the figure; but in the absence of accurate measurements of i or c_p in this region, it is not worth while to complicate the equations by assuming a less simple form for the function $\phi(T)$. The recent work of Smith [1] points to the conclusion that all measurements of the latent heat are probably somewhat in error and that all the points in Fig. 5 are too low; hence the exact value of i near 32 deg. are uncertain. No accurate measurement of $(c_p)_{sat}$ near 32 deg. is available. At present, therefore, we must be satisfied with the following general conclusions:

a The value of $(c_p)_{sat}$ at 32 deg. probably lies between 0.42 and 0.45.

b The curve representing $\phi(T)$ probably lies somewhat above the line $\phi(T)=0.367+0.0001T$ (Fig. 8).

c The curve that represents the relation $i_{sat}=f(T)$ lies very close to the curve of Fig. 5. If Smith's criticism of the latent heat measurement is just, the curve as a whole should be raised.

46 The most important conclusion that may be derived from this discussion is that the analysis is adequate to furnish consistent results when accurate experimental data are available. With accurate measurements of i near 32 deg., the function $\phi(T)$ may be determined and from this accurate value of c_p may be obtained. Conversely, if c_p is accurately determined at 32 deg. and at points in that vicinity, so that the function $\phi(T)$ may be established, then the course of the curve for i_{sat} will be determined.

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[1] Physical Review, September 1911.

STRENGTH OF STEEL TUBES, PIPES AND CYLINDERS UNDER INTERNAL FLUID PRESSURE

By Reid T. Stewart

ABSTRACT OF PAPER

A comparison of the theoretical formulae for the strength of steel tubes, pipes, and cylinders under internal fluid pressure shows that:

a Clavarino's formula is theoretically correct for cylinders with attached heads, and Birnie's formula for heads held independently. These formulae are practically applicable to certain classes of seamless steel tubes and cylinders and to critical examination of ordinary commercial steel tubes, pipes and cylinders when sufficiently accurate data are available.

b In commercial welded pipe the variation in thickness of wall, perfection of weld, etc., account for variation in bursting strength of sufficient magnitude to render unnecessary any consideration of Clavarino's or Birnie's condition of head support. All such variations give rise to errors on the side of danger when applying these formulae.

c For ordinary commercial wrought pipe Barlow's formula is to be preferred. This formula is

$$\frac{p}{f}=2\frac{t}{D};\quad p=2f\frac{t}{D};\quad t=\tfrac{1}{2}D\frac{p}{f};\quad f=\tfrac{1}{2}D\frac{p}{t}$$

where D = outside diameter in in.
t = nominal or average thickness of wall in in.
p = internal fluid pressure in lb. per sq. in.
n = safety factor as based on ultimate strength
f = fiber stress in lb. per sq. in.
$=\frac{40,000}{n}$ for butt-welded steel pipe
$=\frac{50,000}{n}$ for lap-welded steel pipe
$=\frac{60,000}{n}$ for seamless steel tubes
$=\frac{28,000}{n}$ for wrought-iron pipe

STRENGTH OF STEEL TUBES, PIPES AND CYLINDERS UNDER INTERNAL FLUID PRESSURE

By Reid T. Stewart, Pittsburgh, Pa.
Member of the Society

PART I. A COMPARISON OF THE THEORETICAL FORMULAE

In order to arrive at some definite conclusion as to what formula or formulae should be used for calculating the strength of tubes, pipes and cylinders subjected to internal fluid pressure, the different published formulae have been investigated and compared. These are five in number, namely, the common formula, and those by Barlow, Lamé, Clavarino, and Birnie.

2 These formulae have been put into the simplest form for application to tubes, pipes and cylinders, and are reduced to a common notation for the sake of making an easy comparison. The notation used is as follows:

D_1 = outside diameter in inches.
D_2 = inside diameter in inches.
t = thickness of wall in inches.
p = internal gage pressure, or difference between internal and external fluid pressures, in lb. per sq. in.
f = fiber stress in the wall in lb. per sq. in.

3 The formulae here given are for the usual conditions of practise, namely, where the external pressure is atmospheric and the internal pressure is expressed as gage pressure. They are also applicable to cases where the external pressure is not excessive by taking p as the difference between the internal and external pressures.

4 In all that follows it is assumed that the length of the tube or pipe relative to its diameter is sufficiently great to eliminate the influence of end support tending to prevent rupture.

5 *Nature of Stress in Tube Wall.* An internal fluid pressure may give rise (*a*) to a circumferential stress within the wall of a tube or pipe, or (*b*) to both a circumferential and a longitudinal stress acting

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jointly. In either case the tube wall is under radial compressive stress as indicated by the arrows, Figs. 1 and 2.

6 Fig. 1 illustrates a tube with frictionless plungers fitted into its ends, the plungers being kept in place by the external forces, *PP*, which exactly balance the internal fluid pressure tending to force them outward. In this case the tube wall is subjected only to the internal forces shown as acting at right angles to its inner surface. It is obvious that these forces can give rise to radial and circumferential stresses only in the tube wall. The value of the circumferential stress, f_t, in lb. per sq. in. is

$$f_t = p\frac{D_2}{D_1 - D_2} = \frac{pD_2}{2t} \ldots\ldots\ldots\ldots [1]$$

7 Fig. 2 illustrates the ordinary case of a tube or pipe with both ends closed. In this case the tube wall, as in Fig. 1, is subjected to the circumferential stress, f_t, along with the radial stress, and at the same time is subjected to the longitudinal stress, f_l. The longitudinal stress is caused by the internal fluid pressure tending to force the attached heads outward and expressed in lb. per sq. in. is

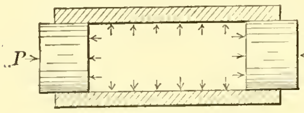
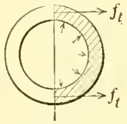


FIG. 1



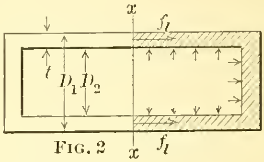


FIG. 2

FIG. 1 TUBE WITH FRICTIONLESS PLUNGERS

FIG. 2 TUBE WITH BOTH ENDS CLOSED

$$f_l = p\frac{D_2^2}{4(D_2+t)t} \ldots\ldots\ldots\ldots [2]$$

When the thickness of wall t, is relatively small with respect to the diameter, the longitudinal stress becomes approximately

$$f_l = \frac{pD_2}{4t} \ldots\ldots\ldots\ldots [3]$$

or one-half the corresponding circumferential stress.

8 *Common Formula.* This is the formula generally found in books on mechanics. It is based on the condition that the tube wall is subjected to circumferential stress only, Fig. 1, and assumes (*a*) that the material of the tube wall is devoid of elasticity, and (*b*) that the stress is the same on all the circumferential fibers from the innermost to the outermost. These assumptions are only approxi-

mately true for tubes of comparatively thin walls, and are greatly in error for tubes having very thick walls.

9 Using the notation as given above, the formula is

$$\frac{p}{f}=2\,\frac{t}{D_2};\quad p=2\,f\,\frac{t}{D_2};\quad t=\tfrac{1}{2}\,D_2\,\frac{p}{f};\quad f=\tfrac{1}{2}\,D_2\,\frac{p}{t}\ldots\ldots\ldots\ldots[4]$$

10 Referring to the charts, Figs. 3 and 4, it will be seen that the common formula gives quite close results for comparatively thin walls when used for the conditions shown in Fig. 1, for which Birnie's formula is theoretically correct. The error increases as the thickness of wall becomes relatively greater, reaching 10 per cent for a thickness ratio $\frac{t}{D_1}$, of about 0.05. For thick walls the error is great; for example, when $\frac{t}{D_1} = 0.25$ the value of $\frac{p}{f}$ is about 100 per cent in error. It should be observed when applying the common formula to this case that the error is always on the side of danger.

11 For the conditions shown in Fig. 2, that is, when the tube is subjected to the stresses due to an internal fluid pressure acting jointly on the tube wall and its closed ends, for which Clavarino's formula is theoretically correct, the curves show for a thickness ratio, $\frac{t}{D_1}$, less than 0.07 that the common formula errs on the side of safety, the greatest error being about 12 per cent; while for thickness ratios greater than 0.07 the error is on the side of danger, reaching 10 per cent for a thickness ratio of 0.1 and about 100 per cent for a ratio of 0.25.

12 *Barlow's Formula.* This formula assumes (*a*) that because of the elasticity of the material, the different circumferential fibers will have their diameters increased in such a manner as to keep the area of cross-section constant; and (*b*) that the length of the tube is unaltered by the internal fluid pressure. As neither of these assumptions is theoretically correct, this formula can give only approximately correct results. Using the notation given above, this formula is

$$\frac{p}{f}=2\,\frac{t}{D_1};\quad p=2\,f\,\frac{t}{D_1};\quad t=\tfrac{1}{2}\,D_1\,\frac{p}{f};\quad f=\tfrac{1}{2}\,D_1\,\frac{p}{t}\ldots\ldots\ldots\ldots[5]$$

13 It should be observed that while Barlow's formula is similar in form to the common formula, it gives results that are quite different when applied to tubes, pipes, and cylinders having walls of considerable thickness. This is due to the fact that Barlow's formula

is expressed in terms of the outside diameter, D_1, whereas the common formula is expressed in terms of the inside diameter, D_2.

14 Referring to Figs. 3 and 4, it will be seen that Barlow's formula gives quite close results when used for the condition shown in Fig. 1, for which Birnie's formula is theoretically correct. The curves show for the entire practical range of thickness ratios that

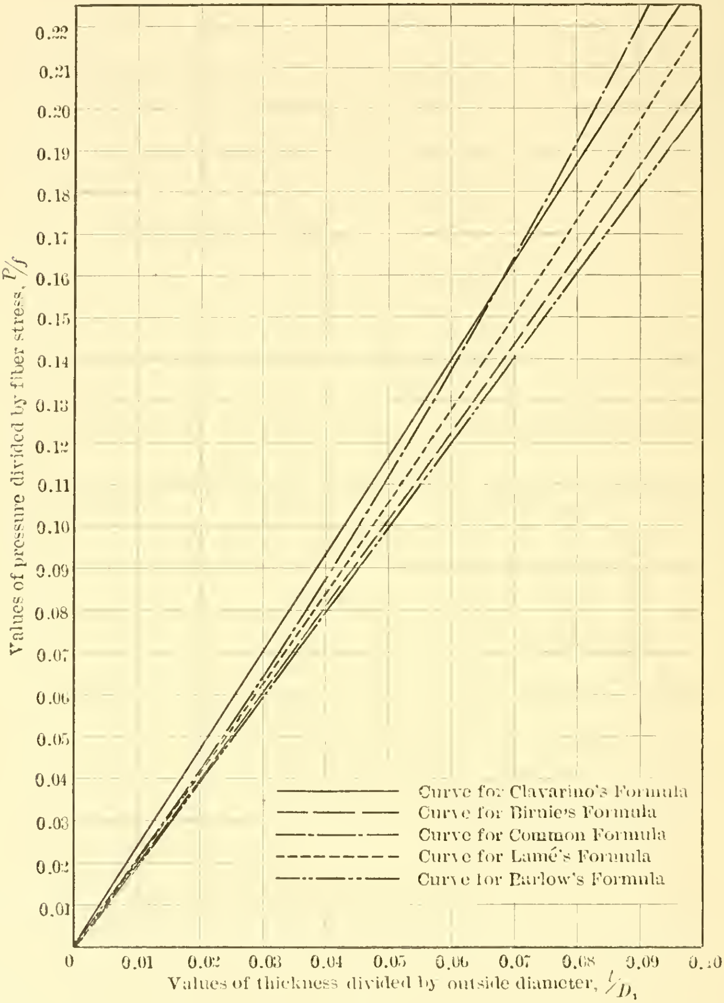


Fig. 3 Comparison of Internal Fluid Pressure Formulae for Tubes, Pipes and Cylinders

the error in values of $\frac{p}{f}$, for this case, does not exceed 3 per cent, the error throughout the whole practical range being on the side of

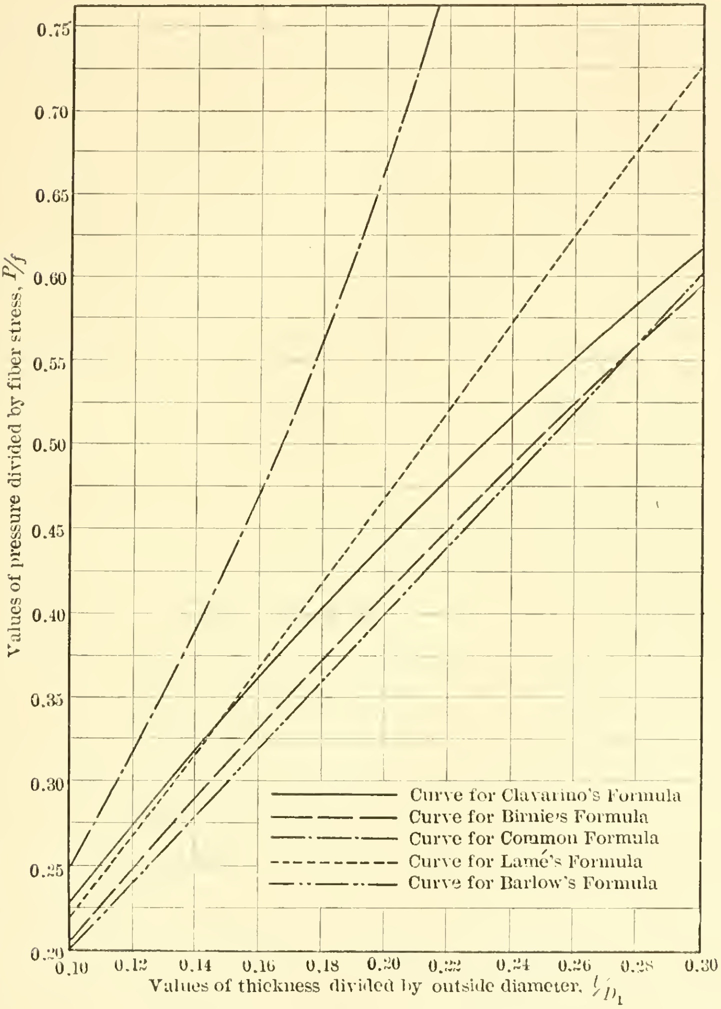


FIG. 4 COMPARISON OF INTERNAL FLUID PRESSURE FORMULAE FOR TUBES, PIPES AND CYLINDERS

safety. This then is the best of the simple theoretical formulae for application to the cases illustrated in Fig. 1.

15 For the conditions shown in Fig. 2, namely when the tube is subjected to the stresses due to an internal fluid pressure acting jointly on the tube wall and its closed ends, for which Clavarino's formula is theoretically correct, the curves show that Barlow's formula gives values of $\frac{p}{f}$ whose errors range from 15 per cent for tubes, pipes and cylinders having thin walls, to 10 per cent for those having thick walls, the error being on the side of safety for all practical thickness ratios.

16 *Lamé's Formula.* This formula is meant to apply to the conditions shown in Fig. 2. Each material particle of the tube wall is supposed to be subjected to the radial compression, the circumferential and longitudinal tensions due to an internal fluid pressure acting jointly on the tube wall and its closed ends; and the material of the tube wall is supposed to be elastic under these actions. Lamé's formula, however, ignores the coefficient of lateral contraction, known as Poisson's Ratio, and consequently is not theoretically correct.

17 Using the notation as given above this formula is

$$\frac{p}{f}=\frac{D_1^2-D_2^2}{D_1^2+D_2^2};\ p=\frac{D_1^2-D_2^2}{D_1^2+D_2^2}f;\ D_2=D_1\sqrt{\frac{f-p}{f+p}};\ D_1=D_2\sqrt{\frac{f+p}{f-p}}\ldots[6]$$

18 Referring to Figs. 3 and 4, it will be seen that Lamé's formula, which is meant to apply to the conditions for which Clavarino's formula is theoretically correct, gives for thickness ratios, $\frac{t}{D_1}$, less than 0.15, an error on the side of safety, the error having a maximum value of about 14 per cent when $\frac{t}{D_1}$ equals 0.01. For thickness ratios greater than 0.15 the error is on the side of danger, reaching 10 per cent for a ratio of about 0.23.

19 *Clavarino's Formula.* In this formula, as in Lamé's formula, each material particle of the tube wall is supposed to be subjected to the radial compression and the circumferential and longitudinal tensions due to an internal fluid pressure acting jointly on the tube wall and its closed ends; and the material is supposed to be elastic under these actions. Unlike Lamé's formula, however, this formula expresses the true stresses in the tube wall as based upon the coefficient of lateral contraction, known as Poisson's ratio, and is consequently theoretically correct for the conditions shown in Fig. 2,

providing the stress on the most strained fiber does not exceed the elastic limit of the material.

20 Using the notation given above and assuming the value of the coefficient of lateral contraction for tube steel to be 0.3, this formula is

$$\frac{p}{f}=\frac{10(D_1^2-D_2^2)}{13D_1^2+4D_2^2}; \quad p=\frac{10(D_1^2-D_2^2)}{13D_1^2+4D_2^2}f; \quad D_1=D_2\sqrt{\frac{10f+4p}{10f-13p}};$$

$$D_2=D_1\sqrt{\frac{10f-13p}{10f+\ 4p}}\ldots\ldots\ldots\ldots\ldots\ldots\ldots[7]$$

21 This theoretically correct formula for the conditions shown in Fig. 2 has the disadvantage that it is difficult to apply directly in making calculations. In order to remove this difficulty Table 1 has been prepared, by means of which any desired calculation can be as readily made by Clavarino's formula as by any of the simpler formulae. The entries of this table are the values in Clavarino's formula of the factor

$$\frac{10(D_1^2-D_2^2)}{13D_1^2+4D_2^2}=K$$

22 It will be observed that these factors are tabulated for thickness ratios, $\frac{t}{D_1}$, from 0.01 to 0.3, advancing by thousandths. Thus for a wall thickness, t, of 0.25 in. and an outside diameter, D_1, of 10 in., the thickness ratio, $\frac{t}{D_1}$, would be 0.25 divided by 10, or 0.025. The required factor corresponding to this thickness ratio is 0.0587 and is found in the column headed 0.005 opposite 0.02 in column 1. Similarly for an outside diameter of 4 in. and a wall thickness of 0.5 in., the thickness ratio would be 0.125 and the corresponding internal pressure factor is 0.2869.

23 If we designate the value of any tabular factor by K, then it is obvious that Clavarino's formula may be written

$$\frac{p}{f}=K; \quad p=Kf; \quad f=\frac{p}{K}\ldots\ldots\ldots\ldots\ldots\ldots\ldots[8]$$

24 Table 1 is well adapted to the ready solution of problems involving the strength and safety of a tube, pipe or cylinder which is subjected to the stresses due to an internal fluid pressure acting jointly on its wall and closed ends, as illustrated in Fig. 2.

Problem 1. Required the safe working fluid pressure, p (Fig. 2), when the outside diameter, $D_1=4$ in.; thickness of wall, $t=0.5$ in.; and the working fiber stress of the steel, $f=10{,}000$ lb. Solution: (*a*) the thickness ratio, $\frac{t}{D_1}=0.125$; (*b*) the corresponding tabular factor, K, is found from Table 1 to be 0.2869; and (*c*) the required safe working fluid pressure, $p=Kf$, equation [8], or $0.2869\times 10{,}000$, or 2869 lb. per sq. in.

TABLE 1 INTERNAL FLUID PRESSURE FACTORS, K, FOR CONDITIONS SHOWN IN FIG. 2

CALCULATED BY CLAVARINO'S FORMULA, ASSUMING FOR STEEL A COEFFICIENT OF LATERAL CONTRACTION (POISSON'S RATIO) = 0.3.

RULE: DIVIDE THICKNESS OF TUBE OR PIPE BY ITS OUTSIDE DIAMETER, BOTH BEING EXPRESSED IN INCHES, THEN MULTIPLY THE TABULAR VALUE CORRESPONDING TO THIS QUOTIENT BY THE WORKING FIBER STRESS IN LB. PER SQ. IN. THE RESULT WILL BE THE SAFE INTERNAL PRESSURE IN LB. PER SQ. IN.

$\frac{t}{D_1}$	0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
0.01	0.0235	0.0259	0.0282	0.0306	0.0329	0.0352	0.0376	0.0399	0.0423	0.0446
0.02	0.0470	0.0493	0.0517	0.0540	0.0564	0.0587	0.0610	0.0634	0.0657	0.0681
0.03	0.0704	0.0727	0.0751	0.0774	0.0797	0.0821	0.0844	0.0867	0.0891	0.0914
0.04	0.0937	0.0961	0.0984	0.1007	0.1031	0.1054	0.1077	0.1100	0.1123	0.1147
0.05	0.1170	0.1193	0.1216	0.1239	0.1263	0.1286	0.1309	0.1332	0.1355	0.1378
0.06	0.1401	0.1424	0.1448	0.1471	0.1494	0.1517	0.1540	0.1563	0.1586	0.1609
0.07	0.1632	0.1655	0.1678	0.1700	0.1723	0.1746	0.1769	0.1792	0.1815	0.1838
0.08	0.1861	0.1883	0.1906	0.1929	0.1952	0.1974	0.1997	0.2020	0.2043	0.2065
0.09	0.2088	0.2111	0.2133	0.2156	0.2178	0.2201	0.2223	0.2246	0.2269	0.2291
0.10	0.2314	0.2336	0.2358	0.2381	0.2403	0.2425	0.2448	0.2470	0.2493	0.2515
0.11	0.2537	0.2559	0.2582	0.2604	0.2626	0.2648	0.2670	0.2692	0.2715	0.2737
0.12	0.2759	0.2781	0.2803	0.2825	0.2847	0.2869	0.2890	0.2912	0.2934	0.2956
0.13	0.2978	0.3000	0.3022	0.3043	0.3065	0.3087	0.3108	0.3130	0.3152	0.3173
0.14	0.3195	0.3216	0.3238	0.3259	0.3281	0.3302	0.3323	0.3345	0.3366	0.3388
0.15	0.3409	0.3430	0.3451	0.3472	0.3494	0.3515	0.3536	0.3557	0.3578	0.3599
0.16	0.3620	0.3641	0.3662	0.3683	0.3704	0.3724	0.3745	0.3766	0.3787	0.3808
0.17	0.3828	0.3849	0.3869	0.3890	0.3910	0.3931	0.3951	0.3972	0.3992	0.4013
0.18	0.4033	0.4053	0.4073	0.4094	0.4114	0.4134	0.4154	0.4174	0.4194	0.4214
0.19	0.4234	0.4254	0.4274	0.4294	0.4314	0.4333	0.4353	0.4373	0.4393	0.4412
0.20	0.4432	0.4452	0.4471	0.4490	0.4510	0.4529	0.4548	0.4568	0.4587	0.4606
0.21	0.4626	0.4645	0.4664	0.4683	0.4702	0.4721	0.4740	0.4758	0.4777	0.4796
0.22	0.4815	0.4834	0.4852	0.4871	0.4889	0.4908	0.4926	0.4945	0.4964	0.4982
0.23	0.5001	0.5019	0.5037	0.5055	0.5073	0.5091	0.5109	0.5127	0.5145	0.5163
0.24	0.5181	0.5199	0.5216	0.5234	0.5252	0.5269	0.5287	0.5304	0.5322	0.5340
0.25	0.5357	0.5374	0.5391	0.5408	0.5426	0.5443	0.5460	0.5477	0.5494	0.5511
0.26	0.5528	0.5545	0.5561	0.5578	0.5594	0.5611	0.5628	0.5644	0.5661	0.5677
0.27	0.5694	0.5710	0.5726	0.5742	0.5758	0.5774	0.5790	0.5806	0.5822	0.5838
0.28	0.5854	0.5870	0.5885	0.5901	0.5916	0.5932	0.5947	0.5963	0.5978	0.5994
0.29	0.6009	0.6024	0.6039	0.6054	0.6069	0.6084	0.6099	0.6114	0.6129	0.6143
0.30	0.6158	0.6173	0.6187	0.6201	0.6216	0.6230	0.6244	0.6259	0.6273	0.6287

Problem 2. Required the fiber stress, f, in the wall of a cylinder, Fig. 2, when the outside diameter, $D_1=5.5$ in., the thickness of wall, $t=0.25$ in.; and the working fluid pressure, $p=1500$ lb. per sq. in. Solution: (*a*) the thickness ratio, $\frac{t}{D_1}=0.045$; (*b*) the corresponding tabular factor, K, is found from Table 1 to be 0.1054; and (*c*) the required fiber stress, $f=\frac{p}{K}$, equation [8], or $1500\div 0.1054$ or 14,200 lb. per sq. in.

Problem 3. Required the thickness of wall, t (Fig. 2), when the outside diameter, $D_1 = 8$ in.; the working fiber stress of the steel, $f = 15{,}000$ lb. per sq. in.; and the working fluid pressure, $p = 2000$ lb. per sq. in. Solution: (*a*) the factor, $K = \frac{p}{f}$, equation [8], or $2000 \div 15{,}000$, or 0.133; (*b*) the value of the thickness ratio, $\frac{t}{D_1}$, corresponding to this value of K is found from Table 1 to be 0.057;

TABLE 2 INTERNAL FLUID PRESSURE FACTORS, *K*, FOR CONDITIONS SHOWN IN FIG. 1

CALCULATED BY BIRNIE'S FORMULA, ASSUMING FOR STEEL A COEFFICIENT OF LATERAL CONTRACTION (POISSON'S RATIO) = 0.3.

RULE: DIVIDE THICKNESS OF TUBE OR PIPE BY ITS OUTSIDE DIAMETER, BOTH BEING EXPRESSED IN INCHES, THEN MULTIPLY THE TABULAR VALUE CORRESPONDING TO THIS QUOTIENT BY THE WORKING FIBER STRESS IN LB. PER SQ. IN. THE RESULT WILL BE THE SAFE INTERNAL PRESSURE IN LB. PER SQ. IN.

$\frac{t}{D_1}$	0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
0.01	0.0201	0.0221	0.0241	0.0261	0.0282	0.0302	0.0322	0.0342	0.0363	0.0383
0.02	0.0403	0.0423	0.0441	0.0464	0.0485	0.0505	0.0525	0.0546	0.0566	0.0586
0.03	0.0607	0.0627	0.0648	0.0668	0.0689	0.0709	0.0730	0.0750	0.0771	0.0791
0.04	0.0812	0.0832	0.0853	0.0873	0.0894	0.0915	0.0935	0.0956	0.0976	0.0997
0.05	0.1018	0.1038	0.1059	0.1080	0.1100	0.1121	0.1142	0.1163	0.1183	0.1204
0.06	0.1225	0.1245	0.1266	0.1287	0.1308	0.1329	0.1349	0.1370	0.1391	0.1412
0.07	0.1433	0.1453	0.1474	0.1495	0.1516	0.1537	0.1558	0.1579	0.1599	0.1620
0.08	0.1641	0.1662	0.1683	0.1704	0.1725	0.1746	0.1767	0.1787	0.1808	0.1829
0.09	0.1850	0.1871	0.1892	0.1913	0.1934	0.1955	0.1976	0.1997	0.2018	0.2039
0.10	0.2059	0.2080	0.2101	0.2122	0.2143	0.2164	0.2185	0.2206	0.2227	0.2248
0.11	0.2269	0.2290	0.2311	0.2332	0.2353	0.2374	0.2395	0.2416	0.2437	0.2457
0.12	0.2478	0.2499	0.2520	0.2541	0.2562	0.2583	0.2604	0.2625	0.2646	0.2667
0.13	0.2688	0.2708	0.2729	0.2750	0.2771	0.2792	0.2813	0.2834	0.2854	0.2875
0.14	0.2896	0.2917	0.2938	0.2959	0.2979	0.3000	0.3021	0.3042	0.3062	0.3083
0.15	0.3104	0.3125	0.3145	0.3166	0.3187	0.3208	0.3228	0.3249	0.3270	0.3290
0.16	0.3311	0.3332	0.3352	0.3373	0.3393	0.3414	0.3434	0.3455	0.3476	0.3496
0.17	0.3517	0.3537	0.3558	0.3578	0.3598	0.3619	0.3639	0.3660	0.3680	0.3700
0.18	0.3721	0.3741	0.3761	0.3782	0.3802	0.3822	0.3842	0.3863	0.3883	0.3903
0.19	0.3923	0.3943	0.3963	0.3983	0.4003	0.4024	0.4044	0.4064	0.4084	0.4104
0.20	0.4124	0.4144	0.4163	0.4183	0.4203	0.4223	0.4243	0.4262	0.4282	0.4302
0.21	0.4322	0.4341	0.4361	0.4380	0.4400	0.4419	0.4439	0.4459	0.4478	0.4498
0.22	0.4517	0.4536	0.4556	0.4575	0.4594	0.4613	0.4633	0.4652	0.4671	0.4690
0.23	0.4710	0.4729	0.4748	0.4767	0.4785	0.4804	0.4823	0.4842	0.4861	0.4880
0.24	0.4899	0.4918	0.4936	0.4955	0.4973	0.4992	0.5010	0.5029	0.5048	0.5066
0.25	0.5085	0.5103	0.5121	0.5139	0.5157	0.5176	0.5194	0.5212	0.5230	0.5248
0.26	0.5266	0.5284	0.5302	0.5320	0.5338	0.5355	0.5373	0.5391	0.5409	0.5427
0.27	0.5444	0.5462	0.5479	0.5496	0.5514	0.5531	0.5548	0.5566	0.5583	0.5600
0.28	0.5617	0.5634	0.5651	0.5668	0.5685	0.5702	0.5718	0.5735	0.5752	0.5769
0.29	0.5786	0.5802	0.5818	0.5835	0.5851	0.5867	0.5884	0.5900	0.5916	0.5933
0.30	0.5949	0.5965	0.5981	0.5996	0.6012	0.6028	0.6044	0.6059	0.6075	0.6091

and (*c*) the required thickness will result from multiplying this thickness ratio, $\frac{t}{D_1}$, by the outside diameter, D_1, or $0.057 \times 8 = 0.456$ in.

Note—When the inside diameter, D_2, the internal pressure, p, and the working fiber stress, f, are given and it is required to find the thickness of wall, t, proceed by finding first the value of the outside diameter, D_1, by means of equation [7]; after which the required thickness may be had by taking one-half the difference of the outside and inside diameters or

$$t=\frac{D_1-D_2}{2}\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ [9]$$

25 *Birnie's Formula.* This formula is based upon the conditions illustrated in Fig. 1. In its derivation precisely the same assumptions are made as for Clavarino's formula, with the single exception that the longitudinal stress, f_1, due to the internal fluid pressure acting upon attached heads, is assumed not to exist. Birnie's formula consequently is theoretically correct for tubes, pipes and cylinders that are subjected to an internal fluid pressure in such manner as not to give rise to longitudinal stress in the wall; provided the stress on the most strained fiber does not exceed the elastic limit of the material.

26 Using the same notation as before and assuming the value of the coefficient of lateral contraction for steel to be 0.3, this formula is

$$\frac{p}{f}=\frac{10(D_1^2-D_2^2)}{13D_1^2+7D_2^2};\quad p=\frac{10(D_1^2-D_2^2)}{13D_1^2+7D_2^2}f;\quad D_1=D_2\sqrt{\frac{10f+7p}{10f-13p}};$$

$$D_2=D_1\sqrt{\frac{10f-13p}{10f+\ 7p}}\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ [10]$$

27 Birnie's formula, like Clavarino's formula, has the disadvantage of being difficult to apply directly in making calculations. In order to remove this difficulty Table 2 has been prepared, the entries being the values in Birnie's formula of the factor

$$\frac{10(D_1^2-D_2^2)}{13D_1^2+7D_2^2}=K$$

28 This table is used in a manner precisely similar to the table of factors for Clavarino's formula.

PART II. RESULTS OF TESTS ON COMMERCIAL TUBES AND PIPES, AND THE APPLICABILITY OF THE THEORETICAL FORMULAE

29 In Part I there appears a full statement of the basis of each of the five theoretical formulae for the strength of tubes, pipes and cylinders, when subjected to internal fluid pressures, together with a comparison of results obtained by their use. One or the other of these formulae, taken apparently at random, has often been used without sufficient understanding of their application to practical conditions. It is the purpose of what follows to illustrate the proper application of these formulae, making use of the results of hydro-

static tests recently made on commercial pipes at one of the mills of the National Tube Company.

30 *Yield Point Tests on Commercial Pipe.* Tests were made under Clavarino's condition, Fig. 2, on 195 specimens of 10-in. and 279 specimens of 12-in. lap-welded steel pipes, all of which were made up into cylinders with heads welded to the pipe. The hydrostatic pressure was raised until the yield point of the material was reached. The unit stresses on the most strained fibers were then calculated by means of Clavarino's formula, the pipes having been measured by micrometer before welding in the head, to determine the least thickness of wall.

31 The average results of the yield points of the most strained fibers of the material constituting these pipes, when compared with the average yield point of tensile test specimens cut from about 400 similar pipes, may be summarized as follows:

Outside diameter of pipe, in	10.00	12.00
Least thickness of wall, in	0.172	0.164
Hydrostatic pressure at yield point, lb. per sq. in	1435	1195
Yield point by Clavarino's formula, lb. per sq. in	35,600	37,100
Yield point average of tensile tests, lb. per sq. in	37,000	37,000
Apparent error in yield point by Clavarino's formula, per cent	−3.8	+0.3

32 This summary of the average results of 474 tests is a very satisfactory confirmation of the accuracy of Clavarino's formula when applied to commercial steel pipes for the conditions under which the formula theoretically applies.

33 Other tests show that when the heads are attached to the pipe, as in Fig. 2, it lengthens upon application of an internal fluid pressure and that when the heads are held independently, as in Fig. 1, it shortens in accord respectively with the assumptions which constitute the basis of Clavarino's and Birnie's formulae regarding change of length under internal fluid pressure.

34 *Applicability of Clavarino's and Birnie's Formulae.* The above summary of results of tests on pipes shows that Clavarino's formula is applicable to commercial wrought-steel pipe for the conditions shown in Fig. 2, when the yield point of the most strained fiber is not exceeded and the least thickness of wall is accurately known.

35 Tests made at the Watertown Arsenal in 1892, 1893, 1894, 1897 and 1902 on sections of steel guns, show that Birnie's formula for the condition shown in Fig. 1, when applied up to the elastic limit of the most strained fiber, gives results which agree with the results of direct tests that are within the ordinary range of experi-

mental error. These Watertown Arsenal tests were all made on tubes the material and dimensions of which were uniform to a degree obtainable only by boring and turning from forgings of the choicest portion of selected ingots.

TABLE 3-a BURSTING TESTS OF COMMERCIAL TUBES AND PIPES

Size	No. of Pieces Burst	Nominal External Diameter, In.	Average Thickness of Walls, In.	Bursting Pressure Pounds per Square Inch			Head Condition*	No. Burst by Failure of Material not at Weld	Average Fiber Stress by Barlow's Formula	Class of Material
				Minimum	Maximum	Average				
					Steel, Butt-Welded					
⅛	10	0.405	0.066	11840	17320	14266	*C*	1	44011	Standard pipe
¼	10	0.540	0.085	8830	14680	12206	*C*	1	38645	Standard pipe
⅜	10	0.675	0.088	5850	13030	10330	*C*	1	39272	Standard pipe
½	10	0.840	0.101	11380	16310	14038	*C*	0	58163	Standard pipe
¾	10	1.050	0.109	7150	9150	8020	*C*	0	38657	Standard pipe
1	10	1.315	0.131	4500	8800	6990	*C*	0	35085	Standard pipe
1¼	10	1.660	1.139	4400	7300	5808	*C*	0	34603	Standard pipe
1¼	15	1.660	0.140	5500	11900	7700	*C*	1	45215	Redrawn
1½	10	1.900	0.143	3000	6100	4960	*C*	0	33031	Standard pipe
2	11	2.375	0.149	3830	6060	4951	*C*	0	40485	Standard pipe
2½	10	2.875	0.198	4310	5740	5134	*C*	0	37351	Standard pipe
3	10	3.500	0.204	4650	6370	5398	*C*	0	46234	Standard pipe
1¼	10	1.660	0.180	7910	14280	10514	*C*	0	48922	Extra strong
2	10	2.375	0.213	7250	8940	8238	*C*	0	45935	Extra strong
2	10	2.375	0.220	6160	8920	7661	*C*	0	41347	Extra strong
2	10	2.375	0.445	8500	18314	14992	*C*	0	40023	X X strong
							General average		41686	
					Steel Lap-Welded					
2	10	2.375	0.155	4890	7940	6645	*C*	1	50962	Standard pipe
2	10	2.375	0.182	4860	10060	7361	*C*	0	47889	Standard pipe
3	10	3.500	0.210	3830	8200	6368	*C*	7	53560	Standard pipe
4	10	4.500	0.232	4810	5680	5249	*C*	1	51462	Standard pipe
5	10	5.563	0.258	3410	5260	4538	*C*	1	48882	Standard pipe
6	5	6.625	0.275	2450	5210	4088	*C*	0	49286	Standard pipe
6	5	6.625	0.275	3170	4760	3666	*B*	0	44106	Standard pipe
10	5	10.750	0.349	3560	4730	4290	*C*	1	66080	Standard pipe
10	5	10.750	0.347	2770	3940	3396	*B*	2	52692	Standard pipe
2	10	2.375	0.218	2500	9870	7909	*C*	0	43254	Extra strong
2	10	2.000	0.108	5100	6560	6062	*C*	7	55607	Boiler tubes
3	10	3.000	0.112	3220	4860	3967	*C*	1	52957	Boiler tubes
4	5	4.000	0.135	3640	4070	3840	*C*	2	56978	Boiler tubes
4	5	4.000	0.136	3720	4040	3914	*B*	1	57440	Boiler tubes
							General average		52225	

* *C* = Clavarino conditions, Fig. 2. *B* = Birnie conditions, Fig. 1.

36 It is apparent that any variation below the nominal or average value in strength of material, thickness of wall and efficiency of joint in welded pipe, or above the nominal in diameter, will give results which err on the side of danger when making use of either Clavarino's

or Birnie's formulae. These formulae then should be restricted in their use to certain classes of seamless tubes and cylinders and to critical examinations of ordinary tubes, pipes and cylinders, when exact results are desired and sufficiently accurate data are available.

37 For all ordinary calculations of strength of commercial tubes, pipes and cylinders, Barlow's simple approximate formula, equation [5], is preferable.

38 *Bursting Tests of Commercial Tubes and Pipes.* Tables 3-a, 3-b

TABLE 3-b BURSTING TESTS OF COMMERCIAL TUBES AND PIPES

Size	No. of Pieces Burst	Nominal External Diameter, In.	Average Thickness of Walls, In.	Bursting Pressure Pounds per Square Inch			Head Condition*	No. Burst by Failure of Material not at Weld	Average Fiber Stress by Barlow's Formula	Class of Material
				Minimum	Maximum	Average				
						Steel, Seamless				
2	10	2.000	0.098	5420	6590	6052	*C*	10	61530	Boiler tubes
3	10	3.000	0.112	3940	4730	4272	*C*	10	57075	Boiler tubes
4	6	4.000	0.134	4160	4440	4318	*C*	6	64450	Boiler tubes
4	4	4.000	0.134	4250	4440	4328	*B*	4	64488	Boiler tubes
							General average		61886	
						Iron, Butt-Welded				
1¼	10	1.660	0.136	2880	6290	5283	*C*	3	32126	Standard pipe
1¼	10	1.660	0.136	3640	5680	4891	*C*	1	29817	Standard pipe
2	10	2.375	0.156	2930	4250	3687	*C*	2	28051	Standard pipe
1¼	10	1.660	0.188	2770	7330	5895	*C*	1	26678	Extra strong
							General average		29168	
						Iron, Lap-Welded				
2	10	2.375	0.152	2400	3940	3213	*C*	1	25122	Standard pipe
2	10	2.375	0.207	5530	7120	6349	*C*	8	36461	Extra strong
							General average		30792	

* *C* = Clavarino conditions, Fig. 2. *B* = Birnie conditions, Fig. 1

and 4 show the average results of several hundred tests of commercial tubes and pipes, all of which were burst by hydrostatic pressure at one of the mills of the National Tube Company. Of these 95 per cent was made by this company, while 86 per cent of the wrought-iron pipe tested was obtained by purchase in the open market.

39 The average ultimate tensile strength of pipe steel is 57,000 lb. per sq. in., whether taken in the direction of rolling or transversely thereto, while that of the seamless steel tested is 60,000 lb. per sq. in. No tensile tests were made of the material of the wrought-iron pipes.

40 An examination of these tables will lead to the following general conclusions:

a In commercial welded pipe the variations in thickness of wall, perfection of weld, etc., give rise to variations in bursting strength of sufficient magnitude to render unnecessary any consideration of Birnie's or Clavarino's

TABLE 4 STRENGTH OF WELDS OF COMMERCIAL TUBES AND PIPES SELECTED FROM PRECEDING TABLE OF BURSTING TESTS

Size	No. Pieces Bursting in Weld[1]	Average Fiber Stress by Barlow's Formula	Class of Material
Steel, Butt-Welded			
⅛	9	43938	Standard pipe
¼	9	37777	Standard pipe
⅜	9	38954	Standard pipe
½	10	58163	Standard pipe
¾	10	38657	Standard pipe
1	10	35085	Standard pipe
1¼	10	34603	Standard pipe
1¼	14	45643	Redrawn
1½	10	33031	Standard pipe
2	11	40485	Standard pipe
2½	10	37351	Standard pipe
3	10	46234	Standard pipe
1¼	10	48922	Extra strong
2	10	45935	Extra strong
2	10	41347	Extra Strong
2	10	40023	X X Strong
General average		41634	
Steel, Lap-Welded			
2	9	50052	Standard pipe
2	10	47889	Standard pipe
3	3	54510	Standard pipe
4	9	51019	Standard pipe
5	9	48852	Standard pipe
6	10	47026	Standard pipe
10	7	59537	Standard pipe
2	10	43254	Extra Strong
2	3	56933	Boiler tubes
3	9	51980	Boiler tubes
4	7	57521	Boiler tubes
General average		51688	
Iron, Butt-Welded			
1¼	7	31136	Standard pipe
1¼	9	30680	Standard pipe
2	8	27323	Standard pipe
1¼	9	27073	Extra strong
General average		29053	
Iron, Lap-Welded			
2	9	24581	Standard pipe
2	2	34340	Extra strong
General average		29461	

[1] These only are included in averages.

condition of head support as shown in Figs. 1 and 2 respectively.

b The relative strengths of steel pipes and tubes, when using Barlow's formula and basing the calculations on average diameter, thickness of wall and ultimate tensile strength of material, are as follows: For butt-welded steel pipe, 73 per cent; for lap-welded steel pipe, 92 per cent; and for seamless steel tubes, approximately 100 per cent. In steel pipe, then, the strength of the butt-weld is about 80 per cent of that of the lap-weld.

c The relative strengths of wrought-iron and steel pipe, from Table 3, are as follows: Butt-welded wrought-iron pipe is 70 per cent as strong as similar butt-welded steel pipe; and lap-welded wrought-iron pipe is 57 per cent as strong as similar lap-welded steel pipe.

41 *Applicability of Barlow's Formula.* Of the five formulae considered in Part I, that by Barlow is the best suited for all ordinary calculations pertaining to the bursting strength of commercial tubes, pipes and cylinders. The theoretical error on the side of safety resulting from its use will generally not exceed the actual combined error on the side of danger when using either Birnie's or Clavarino's formula, due to the ordinary range of variation in the thickness of wall, strength of the material, etc., when applied to the ordinary commercial product. This is true, at least up to the yield point of the material, for any ratio of thickness of wall to outside diameter less than three-tenths. In this respect Barlow's formula is very superior to the common approximate formula which gives errors that are absurdly large on the side of danger for very thick walls (Fig. 4).

42 For all ordinary calculations, then, pertaining to the bursting strength of commercial tubes, pipes and cylinders use Barlow's formula[1] (equation [5]).

$$\frac{p}{f}=2\frac{t}{D_1};\ \ p=2\,f\,\frac{t}{D_1};\ \ t=\tfrac{1}{2}\,D_1\,\frac{p}{f};\ \ f=\tfrac{1}{2}\,D_1\,\frac{p}{t}$$

where

D_1 = outside diameter, in.

---

[1] For certain classes of seamless tubes and cylinders and for critical examinations of welded pipe, where the least thickness of wall, yield point of material, etc., are known with accuracy, and close results are desired, see Clavarino's formulae and Birnie's equations [7] and [10].

t = average thickness of wall, in.
p = internal fluid pressure, lb. per sq. in.
n = safety factor as based on ultimate strength
f = working or safe fiber stress, lb. per sq. in.

$= \frac{40{,}000}{n}$ for butt-welded steel pipe

$= \frac{50{,}000}{n}$ for lap-welded steel pipe

$= \frac{60{,}000}{n}$ for seamless steel tubes

$= \frac{28{,}000}{n}$ for wrought-iron pipe

43 These average values of f are based on the accompanying tables of bursting tests of commercial tubes and pipes. They are intended for substitution in Barlow's formula in case more exact data for the working fiber stress are not at hand.

EQUIPMENT OF A MODERN FLOUR MILL ON A GRADUAL REDUCTION SYSTEM

By John F. Harrison and W. W. Nichols

ABSTRACT OF PAPER

The paper contains a description of a modern flour mill of 4000 bbl. capacity in 24 hours. Detail drawings show the arrangement of machinery, also the drive and history of the development in the art of milling, describing the revolution in the process of manufacturing flour that has taken place in America within the last 40 years. Accompanying figures show the exterior and interior of a mill and elevator of the latest type. The system of a gradual reduction roller mill is also outlined.

EQUIPMENT OF A MODERN FLOUR MILL ON A GRADUAL REDUCTION SYSTEM

By John F. Harrison,[1] Milwaukee, Wis.
Non-Member
and
W. W. Nichols, New York, N. Y.
Member of the Society

The art of milling is one of the most ancient, having been employed by all tribes or nations from the first stages of existence. The mills of the ancients differed little from those at present in vogue in the East and in rural Mexico. They consist of two circular stones, the lower being fixed, having its upper surface made convex so as to fit into a concavity of the upper stone containing a central hole through which the grain is fed to the grinding surface. The upper stone has a pin or handle near the outer edge with which to turn it. This type of mill has remained unchanged in form for from 4000 to 5000 years.

2 An improvement on the ancient hand-mill was made by furrowing, with a system of grooves, the surface of the stones to give a grinding action, at the same time discharging the meal at the periphery of the stones, and the application of animal power to operate them. Public water-mills were mentioned in Roman laws and used in Britain by the Romans. The sluice of one was discovered in Lancashire, in the middle of the last century. This stage in the art of milling brings us to the old grist mill with one run of stone and a sifting reel, generally operated by water power or windmills when the former was not available, and then to the large mills of Europe and America containing several run of stone and a number of reels with machinery for the cleaning of wheat. Milling up to this time had in reality made little progress from ancient times.

[1] Manager, Milling Mchy. Dept., Allis-Chalmers Co.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

3 Oliver Evans, a Colonial Delaware millwright, improved and invented machinery and appurtenances of mills which revolutionized the manufacture of flour. His system of conveyors and elevators made the mill in its operation practically automatic and gave the first impetus to improvement in the mills in this country. In Europe Oliver Evans' mills were referred to as "scientific milling" machines.

4 At the conclusion of the Napoleonic wars when men turned their thoughts to the arts and sciences of peace, the art of milling received its share of attention. Larger mills were erected, water power developed, improvements made in machinery for the cleaning of wheat and the process made more automatic, but still on the lines of the old millstone and the hexagon sifting reel. Merchant mills centered where hydraulic power was available, as at Budapest in Hungary and Richmond, Oswego, Rochester, Milwaukee, St. Louis and Minneapolis in America, these cities each in their turn becoming milling centers but little in advance, as regards engineering, of the Oliver Evans mills.

5 In 1874 Minneapolis mills had a daily capacity of 4500 bbl. of flour, with 190 run of stone, as opposed to the present capacity of 85,000 bbl., one mill alone having 14,000 bbl. daily output.

6 The Washburn mill "A" which rivaled in size and equipment those of Budapest, in Hungary, had 40 run of stone with a daily capacity of 1200 bbl. of flour. About the time of its erection began the most important revolution in the art of milling which has developed the present system and mechanical construction, and the enterprise of the millers of Minnesota in adapting these inventions influenced and encouraged the rapid settlement of the northwestern states of Minnesota and the Dakotas. While the two most important machines, the roller mill and the middlings purifier, as well as the new process of milling, commonly called the Hungarian system, were of European origin, the adapting and improvement in the line of milling machinery and perfecting of the system is very largely the work of American milling engineers.

7 This evolution was carried on in the face of persistent opposition by a conservative class of men who were experts in the old style, a very essential feature of which was the care of the millstone, skill in the dressing and balancing of which required mechanical ability and practice. At the present time this is almost a lost art. By the old system the object was to reduce the wheat to flour at one grinding by a mashing or squeezing process and to obtain the largest amount of flour with the least amount of middlings, since these

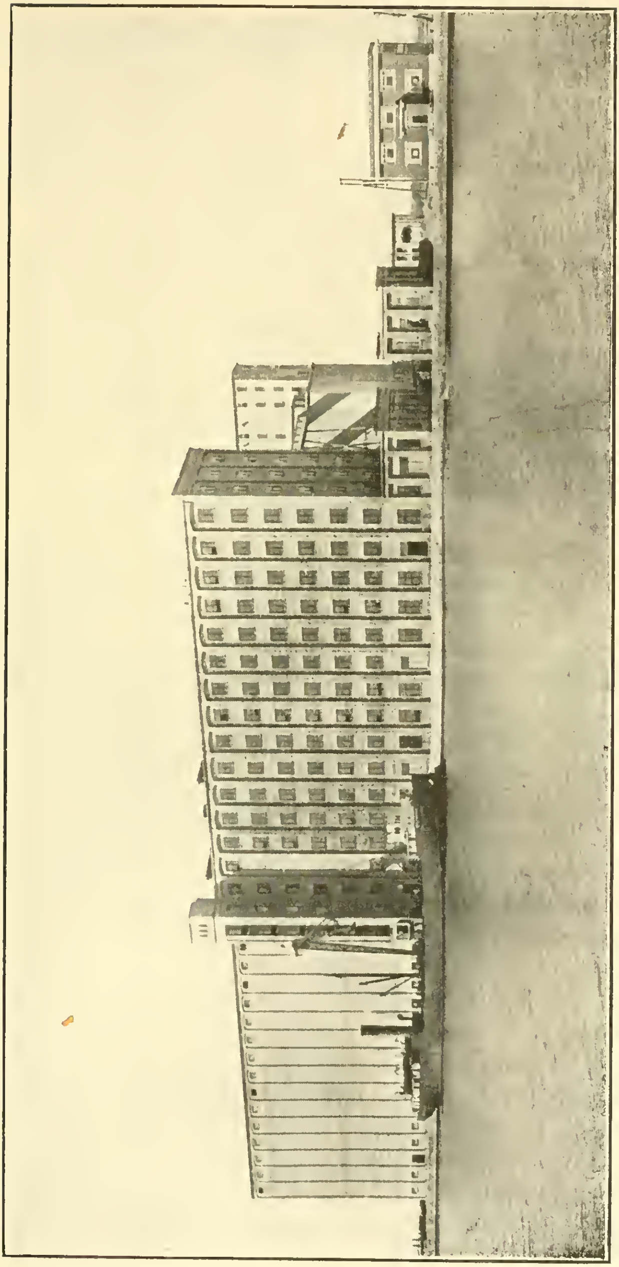


FIG. 1 FRONT VIEW OF MILL BUILDING AND MOTOR HOUSE

contained fine particles of bran and shorts and were available only for a low grade of flour. The new or Hungarian process reversed the old system and ground so as to make as little flour as possible, reducing the wheat to granules which were sifted in a reel clothed with graded silk, thus separating the flour from grits or middlings and bran. The introduction of the middlings purifier made it possible to separate the fine particles of fluff and bran and regrind the purified middlings, producing a higher grade of flour.

8 This new process advanced the price of the hard spring wheat of Minnesota which formerly sold in Eastern markets for 50 cents per bushel less than winter wheat, and Minnesota flour brought from $1 to $2 less per bbl. than the brands manufactured by the St. Louis mills which used the softer varieties of winter wheat. The mills of Minnesota using the new process according to the Chicago market reports of February 1874, sold "strictly fancy" New Process flour at $9.50 to $10.50 per bbl. while choice winter wheat St. Louis flour brought in the same market $8.25 and $9.25 per bbl.

9 The middlings purifiers were used in Europe on the hard varieties of Hungarian wheat some years before their introduction in America. They were of a rather primitive pattern at first, but improved step by step until the Hungarian miller had developed a very elaborate machine. The purification was effected by grading the middlings on sieves, as many as ten separations being made, the offal and fluff being taken off by a suction of air in aspirators. In Hungary the purification of middlings was carried further than was thought necessary in America where a much simpler system requiring less labor to operate was developed.

10 M. Lacroix, a French miller, introduced a middlings purifier into a Minneapolis mill in the early sixties. The construction was a sieve about 30 in. wide, 12 to 16 ft. long, shaken laterally by an eccentric shaft. The box containing the sieve was fitted with a suction fan drawing the air through the silk, the air being admitted through openings in the frame under the silk, which was graded to sift the fine middlings at the head and the coarse toward the tail, the coarse particles of shorts tailing over. The silk required brushing by hand quite frequently to prevent clogging. The application of a traveling brush under the silk was suggested and patented. This was the most successful purifier of the many afterwards put on the market and is the standard middlings purifier today (Fig. 8), displacing the Hungarian machine, not only in America but also to a large degree in Europe.

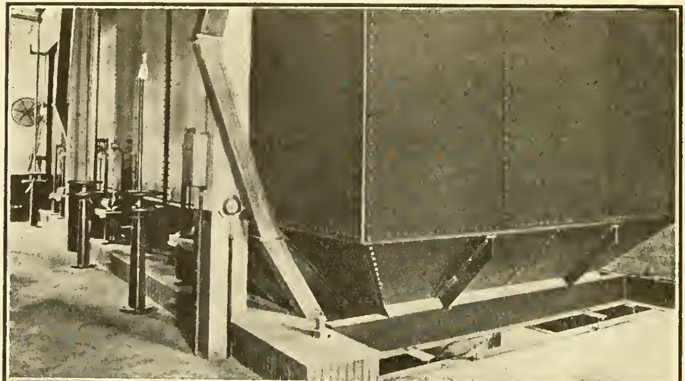
11 In connection with the purifier a settling chamber or dust room was used which occupied a large space of the mill. The dust settled on the floor of the room, and the air inseparable from the fine dust discharged into the open air. This was not only a crude system but wasteful and dangerous, the fine flour dust under certain conditions being as explosive as gunpowder. On May 2, 1878, the large Washburn "A" mill referred to in Par. 6 was destroyed by an explosion of flour dust, leveling the huge stone structure with foundation walls 6 ft. thick and literally leaving not one stone upon another.

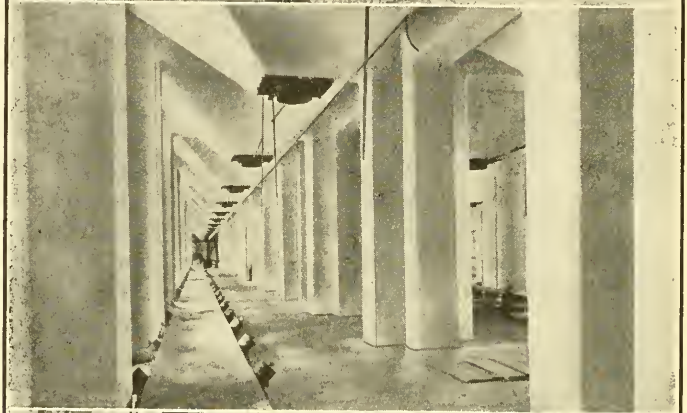
12 This necessitated the present dust collector, an important American invention shown in Fig. 8, which collected the dust in a number of cloth tubes. The air passes through the cloth and the tubes are cleaned by jarring them over a dead air chamber.

13 The roller mill, one of the most important machines in a modern flour mill, was invented about 1833 in Switzerland. For 30 years after their first introduction, however, they were used in but few mills in Europe. The first rolls introduced in Minneapolis in 1874, were crude machines made of cast iron and much secrecy was used in connection with the experiments made. One process of flattening the wheat before grinding was soon abandoned. The fluting of the rolls to grind or scrape the flour from the bran proved a success as it enabled the miller to grind higher and produce more middlings; this was the first step towards gradual reduction. The cast iron being too soft to last, a fluted chilled-iron roll was successfully manufactured and in a short time displaced the millstone for this purpose. The application of fluted rolls for breaking or grinding the wheat was gradually adopted, five to eight operations being made in the gradual reduction of the wheat. After each grinding or break, the product was sent to a reel or scalper, the flour separated and the middlings sent to a purifier while the tailings were delivered to the next reduction on the rolls, the final separation of bran being cleaned in a duster.

14 Oscar Oexle, an engineer and millwright of Augsburg, Bavaria, in 1877 introduced the Wegner porcelain roller mill in America and with it a system of reducing the middlings on porcelain rolls in connection with millstones. Smooth chilled-iron rolls being more durable displaced these porcelain rolls.

15 For some years roller mills were used indiscriminately on different stock in different mills in connection with millstones and to a great extent were an experiment. A complete roller mill, the





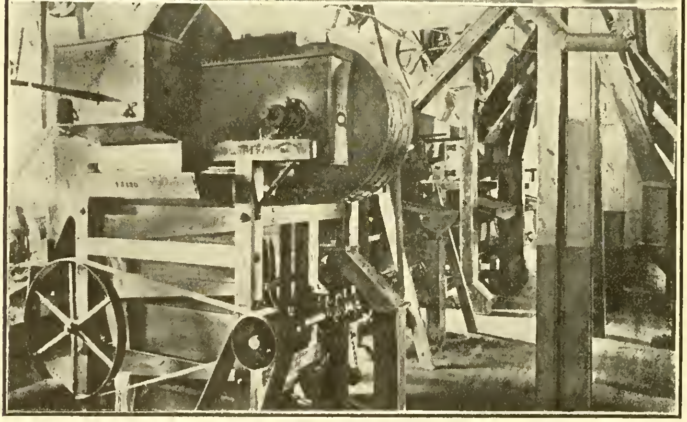


Fig. 2 Three Hopper Scales of 2000 Bushels Capacity Each

Fig. 3 The First Floor of the Elevator showing the Concrete Construction for the Support of the Bins; the Bin Hoppers; the Belt Conveyors for moving the Wheat from the Bins to the Wheat Cleaning House. Similar Belts in the Attic distribute the Wheat into the Bins

Fig. 4 Milling Separators for removing Seeds and Foreign Substances from the Wheat

result of these experiments, was not attempted until 1878 or 1879 when C. C. Washburn built an experimental mill using corrugated and porcelain rolls exclusive of stone. A complete roller mill had been built in Presth, Hungary, and in 1864 an engineer from this mill built one at Fiume, Austria.

16 The old hexagon reels for bolting flour which had been in use in the old style mills were very clumsy pieces of machinery. They were built from 16 to 20 ft. long, but were gradually replaced by shorter round reels and centrifugal reels, about 32 in. in diameter, 8 to 10 ft. long with beaters revolving in the direction of the reel at a higher speed than the cylinder. This was an important improvement. The centrifugal reel was of European origin, but it was improved in the manner of drives and the construction made lighter and simpler. A system of bolting the flour and grading the middlings had been experimented with, requiring less space with the added advantage of having larger capacity.

17 In 1892 a sieve machine was installed in a Minneapolis mill by Carl Haggenmacher that was destined to revolutionize the bolting system of milling. It is a long call from the sifting of the meal by hand as shown in the hieroglyphics of Egypt, and yet these later improved bolting sifters work on the ancient principle of the hand sieve.

18 The plansifter consists of a box with a nest of sieves alternating with blank carriers to take off the different separations. The box is suspended by hangers and a gyrating motion imparted to it by an eccentric in a counterbalanced driving pulley on a vertical shaft attached to the underside of the sieve frame. The introduction of this sifter disabused the minds of many millers of the idea that returns or cut-offs were essential.

19 Next was developed the square sifter, a machine made of four separate square boxes containing a nest of sieves about 20 in. square, placed on top of each other and arranged in series for different separations. The product tails from the upper sieve to the lower or to the discharge spout, the finished product or siftings being gathered under each sieve on blanks and spouted out of the machine through openings in the sides of the frame. The motion of the square sifter as in the plansifter is gyratory, the principle of using the small sieves placed vertically over each other being identical with the use of four short reels 2 ft. long instead of one reel 8 ft. long. The cut-off system is provided for. In the different forms and makes of sifters, the great advantage lies in the floor space required for the

bolting capacity over the reels, which is especially true in the vertically constructed sifters.

20 In 1895 the universal bolter, a sifter of novel construction of the vertical type, was patented and gradually developed first as driven by a crankshaft running in rigid boxes fixed on the top and bottom heads of the frame. The upper end of the shaft ran in a stationary bearing and the bottom in a step set rigid. The frame was counterbalanced at the top and bottom of the shaft by heavy wheels, and the gyrating frame was suspended by rods. The objection to this fixed eccentric was the difficulty of balancing the machine under a varying load which conveyed a vibration to the building. To overcome this was applied a novel patent drive described by the patentee W. Worby Beaumont, as "dispensing entirely with the crank shaft and using rotary balance weights fixed to a straight vertical shaft running in bearings attached to the frame or body to be gyrated. The crank and connecting rod being absent, the balance weights are unbalanced except dynamically and the want of balance is kinetically equivalent to the required motion of the body to be gyrated."

21 To adapt this movement to practical use improvements in the drive connections and a device for restricting the abnormal outward throw of the bolter at starting or stopping or when not running at the critical speed of rotation, have been made and patented.

22 By referring to Fig. 21 the shaft or spindle *A* is carried in bearings attached to the frame *B* to which it is desired to give a gyratory motion. The frame is freely suspended and the shaft and frame attached are restricted to a circle proportional to the inertia of the frame and of the mass of the weight *C* considered with reference to the distance of its center of mass from the center of the shaft *A*. Shaft *A* is driven through a flexible or universal coupling by a driving shaft in a fixed bearing. The unbalanced eccentric weight *C* is carried by an arm secured to shaft *A*. By changing the radius of the weight or adding weight, the radius of the gyratory movement of the frame *B* is increased. A wide range of speed or in the weight of the frame *B* may be used without affecting the diameter of the gyrating circle described by the frame, which is unrestrained except by the flexible suspension rods *D*. When in motion considerable pressure would be required to throw it out of its gyrating circle. The pins *E* at the top and bottom of the shaft are adjusted to half the throw of the frame; centers plumb and steady when running at the critical speed of rotation. This movement is

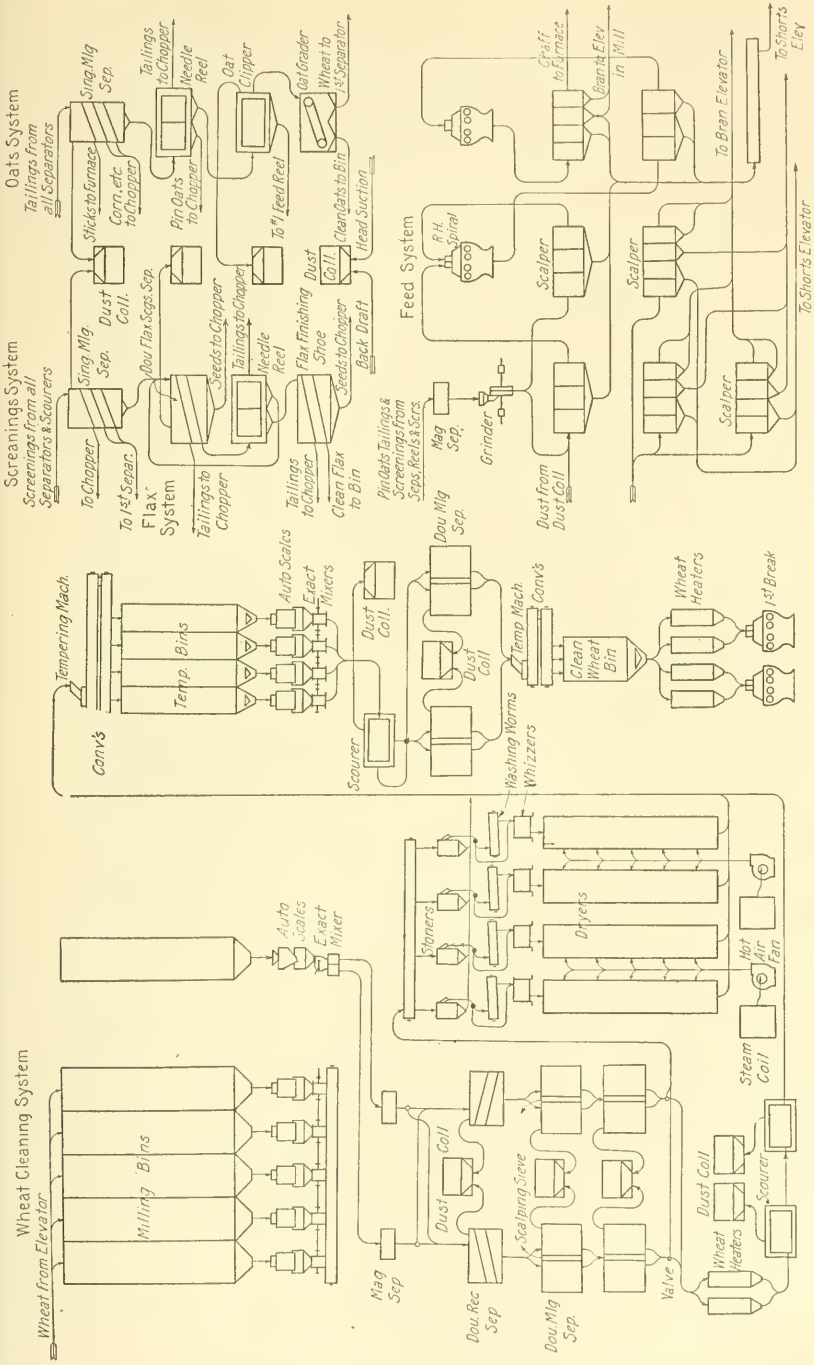
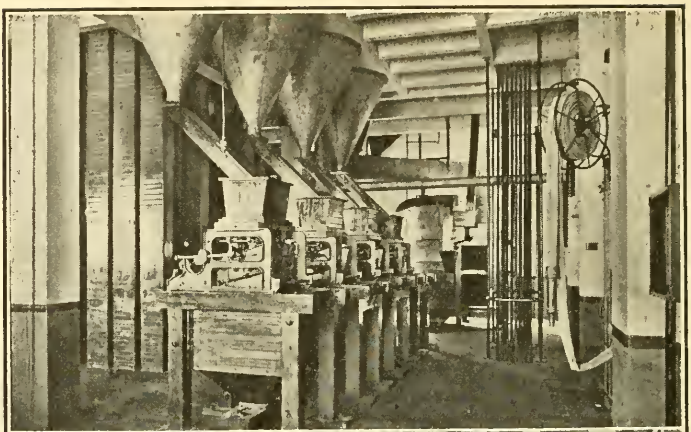
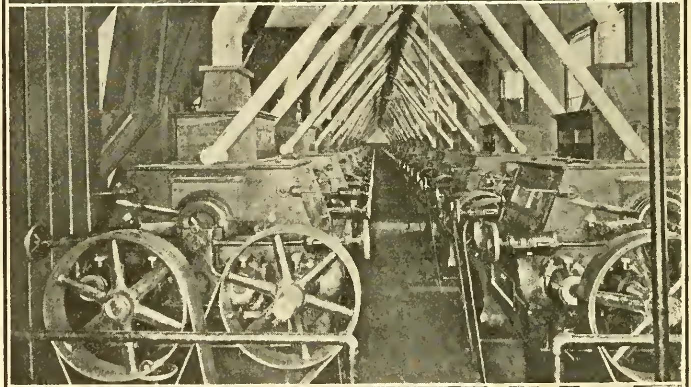


FIG. 5 DIAGRAM OF THE PROCESS OF CLEANING THE WHEAT





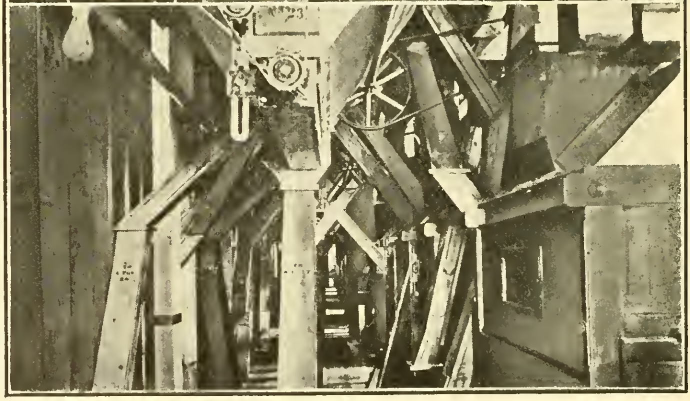
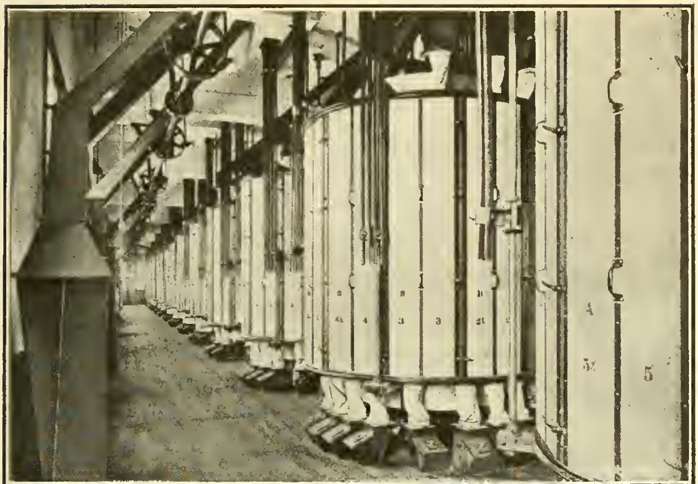
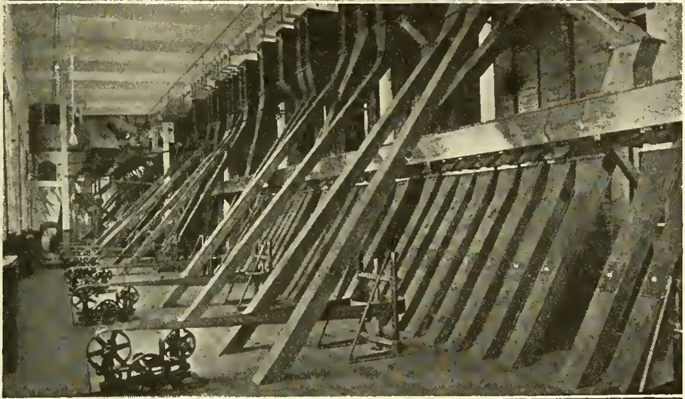


Fig. 6 Automatic Scales for Weighing the Wheat from the Elevator into the Mill

Fig. 7 View of the Roller Mills on the Second Floor

Fig. 8 View of the Purifiers and Partial View of the Dust Collectors on the Fifth Floor





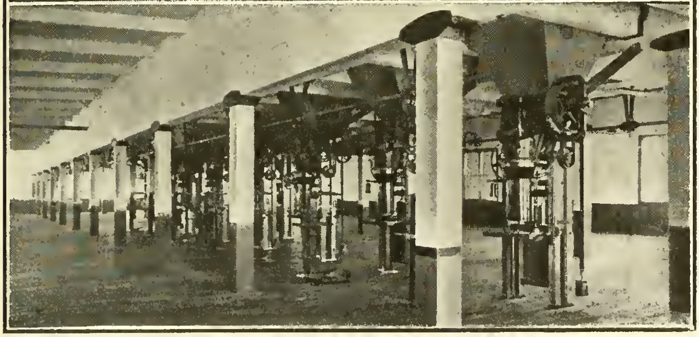


Fig. 9 View of the Sixth Floor showing the Universal Bolters

Fig. 10 View of the Attic, or Seventh Floor, showing the Arrangement of Spouts from the Elevators to the Universal Bolters and the Belt Drive for the Universal Bolters

Fig. 11 View of the Packing Floor showing the Flour Packers in the Fourth Story of the Warehouse

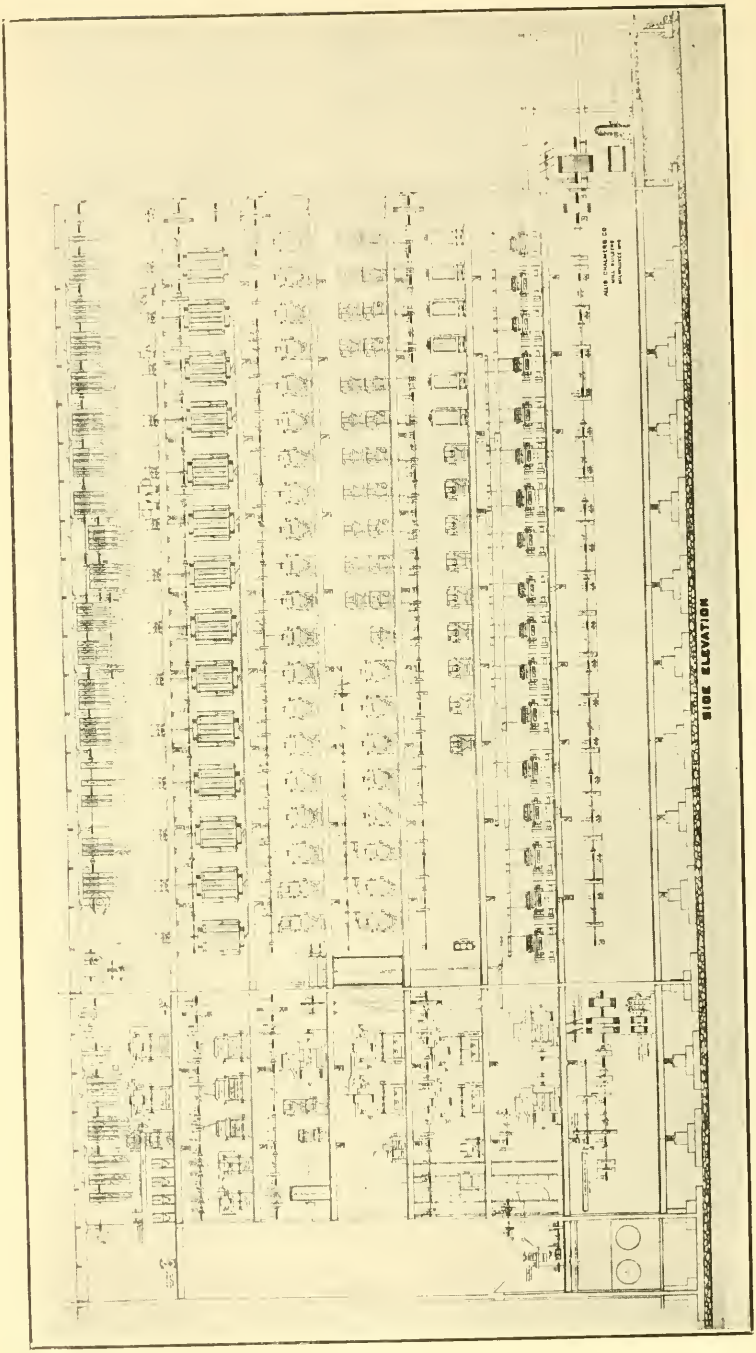


Fig. 12 Longitudinal Section of the Mill, Motor-Drive House and Wheat Cleaning House

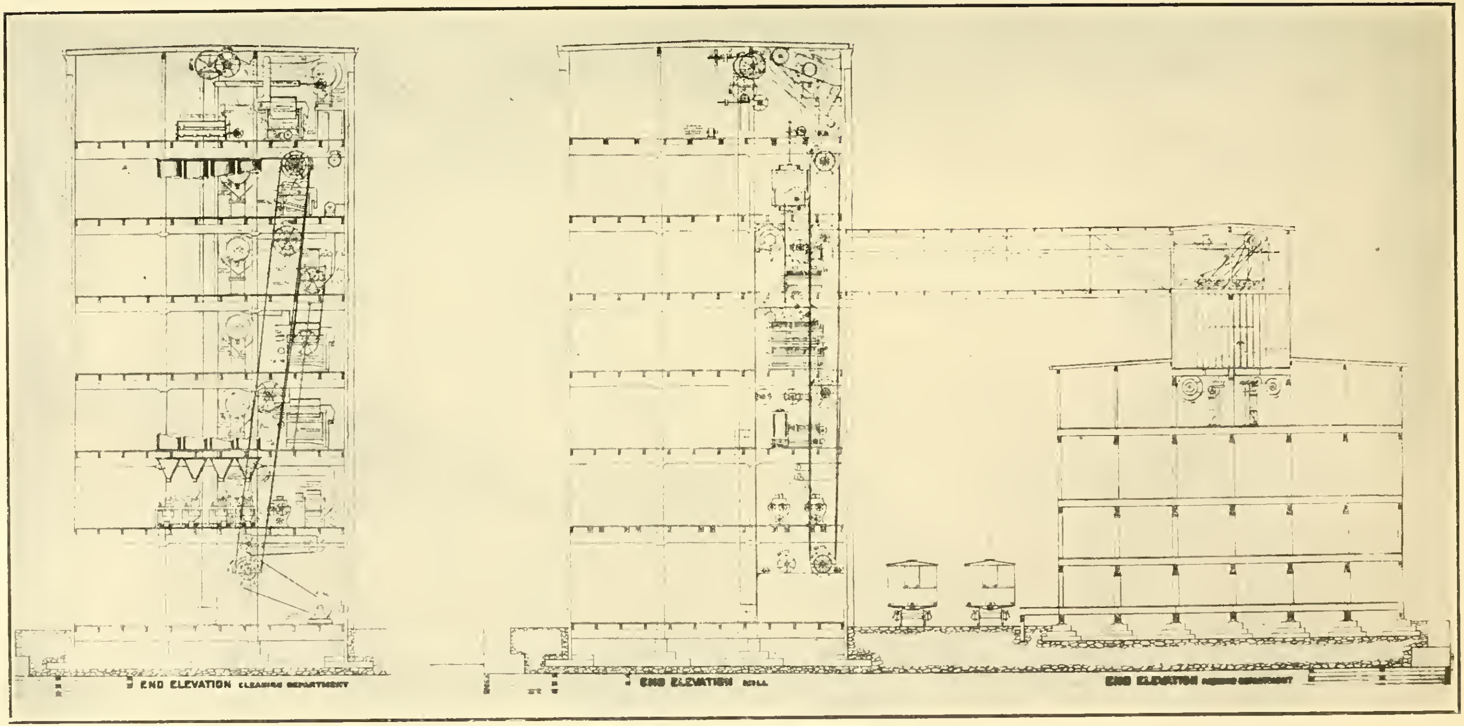


Fig. 13 Sectional Drawing of the End Elevation of the Mill showing Packing Room in the Fourth Story of the Warehouse, also Section of the End Elevation of the Wheat Cleaning Room

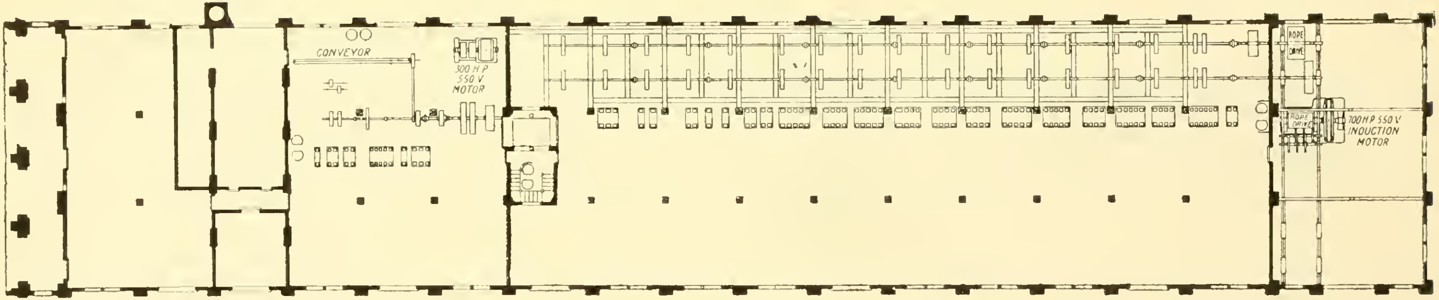


Fig. 14 First Story Detail Drawings of the Mill and Cleaning House

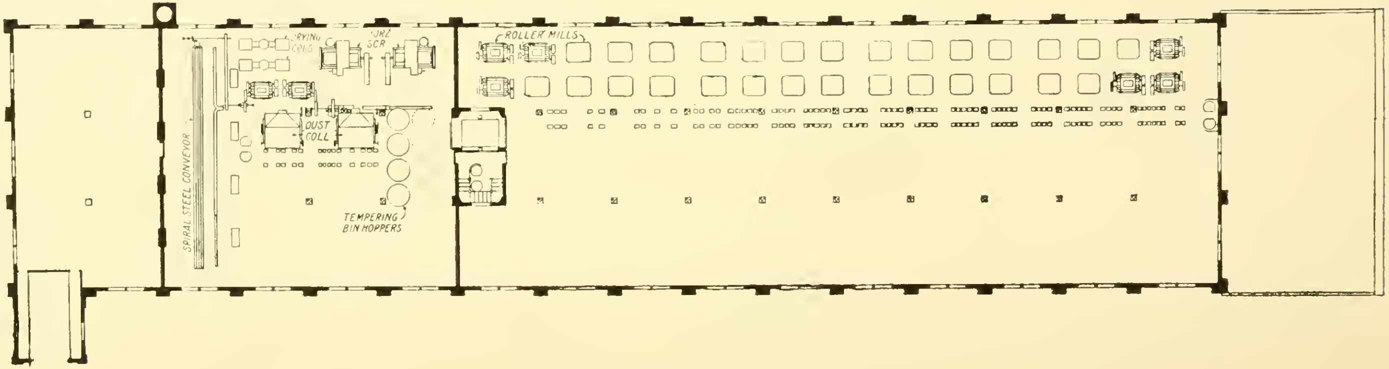


Fig. 15 Second Floor Plan

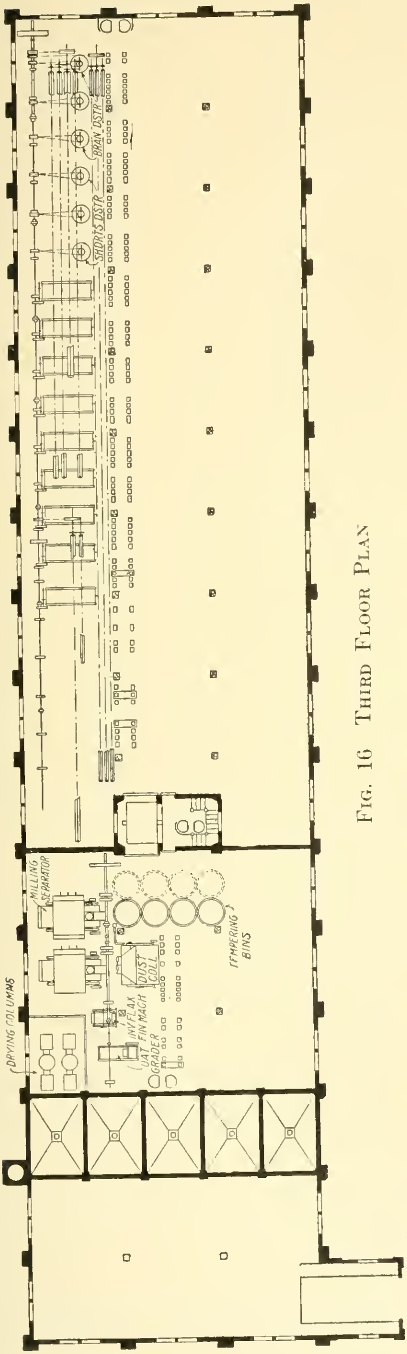


Fig. 16 Third Floor Plan

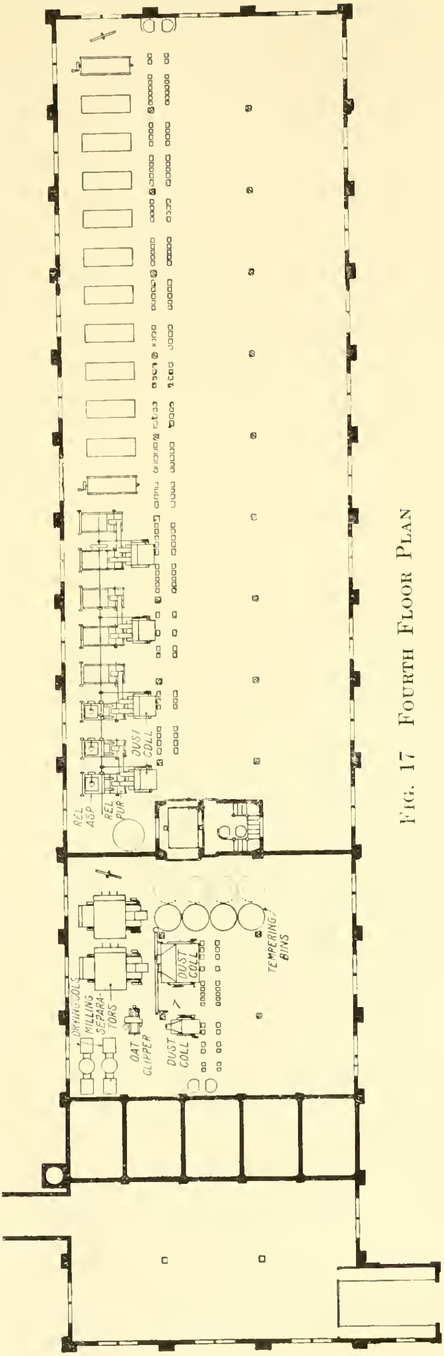


Fig. 17 Fourth Floor Plan

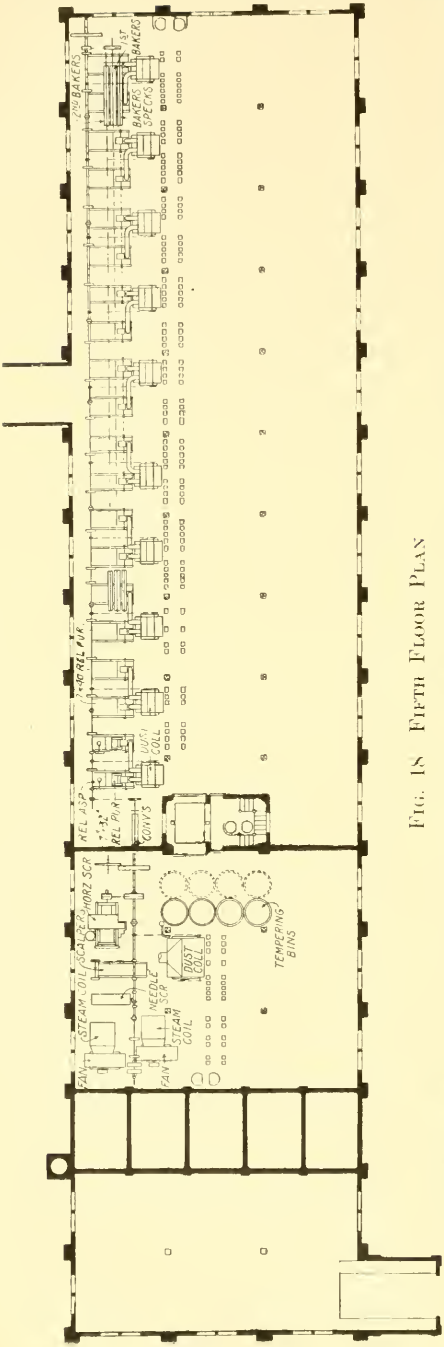


Fig. 18 Fifth Floor Plan

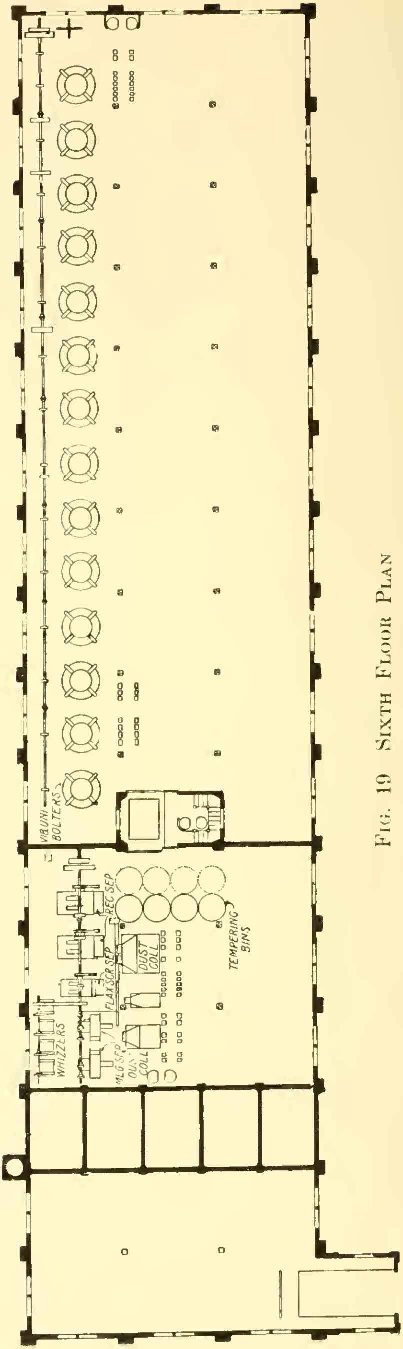


Fig. 19 Sixth Floor Plan

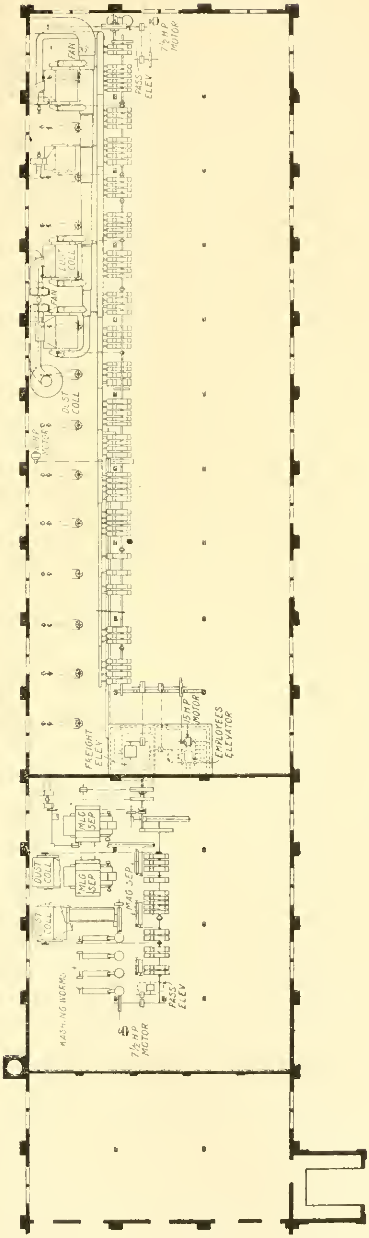


Fig. 20 Seventh or Attic Floor Plan

called a vibromotor drive because a large part of the motion imparted by it is the result of converting into useful work the waste of eccentrics.

23 The arrangement of sieves in the universal bolter is a novel system. The frame is dodecagon and the conical sieves are supported in grooved slides, each sieve having a drop of ½ in. and set level in the frame. The ½ in. drop in each sieve continues around the 12 sides, forming a series of descending spirals and affording a continuous bolting surface proportioned to the requirement. The material is admitted to the head sieve by spouts in the outside doors and discharged where necessary through similar spouts. The principle of gyrating sieve bolting is that the stock is not continually tossed and mixed as in a reel, but is sifted through the silk, the fluff being floated on the top of the stock over the tail leaving a brighter and purer flour.

24 An important factor in a flour mill is the cleaning machinery, consisting of separators for removing chaff, straw, foreign seeds, etc., and scourers for polishing the wheat and removing the dust. Washers and dryers are also essential appurtenances.

25 The tempering of the wheat requires the greatest attention and skill as the varieties grown in the different sections need different treatment to obtain the best results. The analysis and chemistry of wheat are being given much attention by most of the state agricultural colleges with the object of improving the quality and selecting the varieties of wheat best adapted for milling purposes. Science is being applied to the art of milling and the utmost care is used in selecting a mixture that insures the requisite qualities of a good bread-making flour. There is no food manufactured that is purer or so entirely free from adulterations.

26 This brief history of the development in the art of milling in America will suffice to introduce a description of a modern flour mill built on a system which has been evolved step by step. It is the product of many minds; many features are peculiarly American, especially the labor saving devices.

27 Within the last few years the tendency has been to build mills of large capacities ranging from 2000 to 6000 bbl. every 24 hours. For such mills the merchant miller chooses a location having advantageous traffic rates, cheap power and near to the market. Some representative mills of this class are the mill in New York City of 10,000 bbl. capacity in two units; the 13,000 bbl. mill in three units (one 7000 and two 3000 bbl. each) in Buffalo; 5000 bbl. in one unit

in Keewatin, Ontario; 2500 bbl. in one unit in Montreal; the 4000 bbl. in one unit at Winona, Minn., now building; the Maple Leaf Milling Company of 4000 bbl. capacity in one unit at Port Colborne, Ontario. The last two mills are to have an ultimate capacity of 9000 bbl. each.

28 These mills are water, steam and electrically driven and represent the latest and most advanced types both in mechanical construction and in the art of milling. The Maple Leaf Mill at Port Colborne has been selected for the subject of illustration as it is the latest complete mill in operation. It is electrically driven, Fig. 1 showing the power station which contains three 800-kw. transformers taking power from Niagara at 23,000 volts and transforming to 550 volts.

29 The front view of the mill (Fig. 1) shows the motor house, the mill building 60 ft. by 264 ft. and seven stories high. The storage elevator of 60 bins of 15,000 bushels each, with the storage capacity in the mill makes the present wheat storage capacity 1,000,000 bushels. On the installation of the second unit 40 additional bins are to be added, making a total capacity of 1,600,000 bushels. The marine leg shown in elevation has a capacity of 28,000 bushels per hour. The mill is located at the entrance of the Welland Canal, and boats of 20 ft. draft carrying 350,000 bushels of wheat can be loaded from the great elevators at Fort William or Duluth at the head of Lake Superior and discharge their cargo without breaking bulk directly into the mill elevator. At the close of navigation the boats are used for the storage of their last shipment, until the opening of navigation, thus greatly increasing the storage capacity. The elevator is entirely of reinforced concrete construction; the mill building walls are of a similar material and the interior is of timber.

30 The three hopper scales each of 2000 bushels capacity, in which the wheat from the marine leg is weighed, are shown in Fig. 2. Fig. 3 is a view in the elevator showing the two traveling belts for moving the wheat from the bins to the wheat cleaning house. On the top floor are similar belts from which the wheat is spouted to the different bins.

31 A diagram of the process of cleaning the wheat is shown in Fig. 5. The wheat after passing over receiving separators is delivered to the storage bins in the wheat cleaning house, after which it is weighed on automatic scales and passed over a magnetic separator. It is then spouted over sieve separators to remove the foreign

matter and from these receiving separators over the milling separators. There are four of these milling separators, the stream being split as shown in the diagram, thus affording a double separation. From these milling separators the clean wheat passes through heaters or tempering machines, the object being to toughen the outside coating of the wheat or bran. It then goes through the process of scouring to remove the fluff or beard on the wheat, this action producing a polish on the grain. From these scourers the wheat is spouted to the wetting conveyors. A certain amount of water is applied to the wheat with the object of properly tempering and conditioning the grain. From the tempering bins it is weighed over automatic scales and the difference between the gross weight and this net weight gives the exact amount of seeds and dust or loss between the wheat from the elevator and the clean wheat going to the first reduction in the mill. After being weighed on these automatic scales it is given another scouring and passed over another milling separator to remove what dust has accumulated in the process. Tempering conveyors are used before spouting the product to the clean wheat bins. From these bins it passes through a set of wheat heaters in order to keep the tempering uniform just before being spouted to the first break roller mills in the grinding process.

32 In case the wheat is smutty or dirty it is switched after leaving the first four milling separators, as shown by the valve in the diagram, to stoners and washing machines. After being thoroughly washed it is passed through whizzers which separate the water from it. The wheat is then passed through dryers in which both hot and cold air is used. The process after leaving the dryers is the same as in the case of the wheat not washed. Figs. 4 and 8 show sections of the wheat cleaning department.

33 There are other systems of screening machines used for separating the flax, oats and mustard seeds.

34 Fig. 12 is a longitudinal section of the mill, motor-drive house and wheat cleaning house. The first floor shows the two lineshafts for driving the double line of roller mills; the second or roller floor shows 14 double pair of 10 by 42 and 20 double pair of 10 by 36 roller mills (Fig. 7); the third floor has a few reels, six bran and shorts dusters, conveyors for gathering flour from the different bolters, and spouting to the rolls and elevators; the fourth floor contains 23 centrifugal reels for dressing the lower grades of flour and for blending and mixing purposes; the fifth floor contains the middlings purifiers (Fig. 8), of which there are 28 and dust collectors

for every two purifiers; the sixth floor is the bolting floor containing 14 vibromotor universal bolters (Fig. 9) of the largest capacity; the seventh floor is the attic showing the elevator lineshafts and the drives for universal bolters.

35 The universal bolters will take care of a stream on the breaks for a 5000 bbl. mill. The main stream is divided into eight parts. The first separation is over a 24 wire, the tail of which is spouted through spouts to the fifth break rolls; the sifts of the 24 wire pass over 32 wire to the coarse middlings purifiers; the stock sifted through the 32 wire is bolted over a 46 special wire and the tails spouted to the first middlings purifiers; the sifts of the 46 wire are bolted on to 58 special wire and the tail spouted to the second middlings purifiers; the sifts of the 58 special wire are dropped to a 72 special wire and tailed to the third middlings purifier; the sifts of the 72 are bolted on No. 9 silk, the tail going to the fourth middlings reduction and the siftings to the flour dresser. Thus it will be noted that six separations are made on this machine. The spiral arrangement of the sieves enables the stock to flow continuously over the wire or silk until the separation is completed and the amount of wire may be proportioned to the amount of dusting or scalping required. The single machine has a capacity of ten centrifugal reels and occupies a floor space of 36 sq. ft. All the space required for the bolting capacity of a 4000 bbl. mill as shown in Fig. 19 is 4920 sq. ft.

36 A view of the attic or seventh floor of the mill, the arrangement of spouts from the elevators to the universal bolters and the belt drive for the universal bolters is shown in Fig. 10.

38 Fig. 13 is a sectional drawing of the end elevation of the mill and packing room (see also Fig. 11); Figs. 14 to 20 are detail drawings of the various floor plans of the mill.

39 A 700-h.p. induction motor of the wound rotor type, running at a speed of 485 r.p.m. drives the two lineshafts. It is supplied with current at 550 volts and $66\frac{2}{3}$ cycles. The wound rotor type is used in order to obtain a high starting torque, necessary for flour-mill work, with moderate live current.

40 The sheave on the motorshaft is 40 in. in diameter, 36 grooves for $1\frac{1}{4}$-in. rope divided into three sections of 12 ropes, each section having a separate take-up; the first 12 ropes drive one roller lineshaft, the remaining 24 drive the other lineshaft for which the drive for the upper part of the mill is taken off by a rope sheave 64 in. in diameter, 9 grooves, $1\frac{3}{4}$-in. rope.

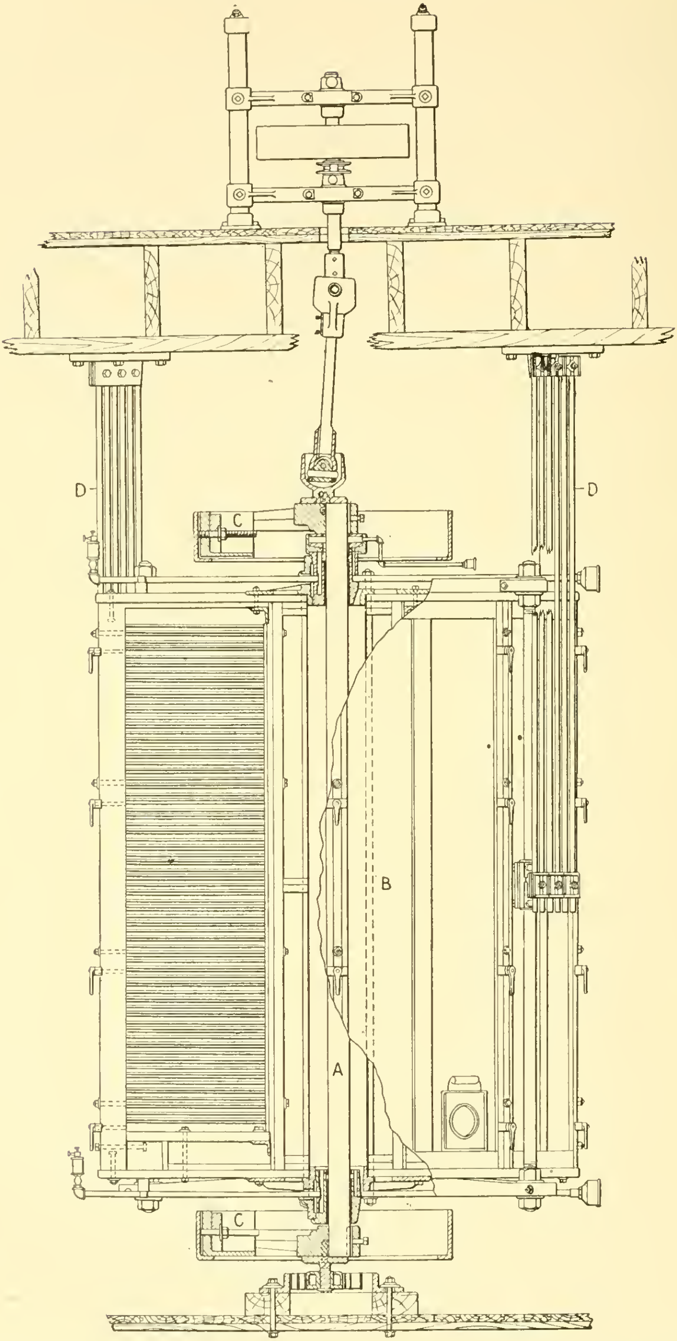


FIG. 21 UNIVERSAL BOLTER WITH NOVEL ARRANGEMENT FOR PRODUCING GYRATORY MOTION OF FRAME

41 The cleaning machinery is driven by a 300-h.p. wound rotor motor running at 485 r.p.m., the sheaves on the motorshaft being 38 in. in diameter, 16 grooves, 1¼-in. rope driving an 80-in. sheave on the lineshaft. The upstairs machinery is driven from this lineshaft by a 64-in. sheave, 8 grooves, 1¾-in. rope. The marine leg, the wheat receiving machinery in the elevator and the flour packers are all driven by separate motors.

42 The engineering and mechanical construction of a flour mill is carried out with the object of incorporating a system of milling to produce results in the manufacture of flour as regards quality, yield and percentages of the different grades.

43 The majority of American mills make seven grades of flour, first and second patent, first and second clear commonly called baker's flour, low grade and red dog; or by blending the four first grades making a straight grade of flour. The percentages and yield vary according to the quality of the wheat.

44 Using a good grade of wheat and making a yield of 4 bushels and 16 lb. to a bbl. (196 lb. of flour) it is possible to obtain 61½ per cent patent flour, 9.2 per cent of baker's flour, 3.7 per cent of low grade, 2.4 per cent of red dog, leaving 23.5 per cent of offal which includes bran and shorts. The quality of the two low grades of flour of course would be governed by the yield and the closer the yield, the poorer those grades of flour would be.

45 The clean wheat from the tempering bins is delivered to the first two stands of 10 by 42 roller mills. These are corrugated or grooved with special patterns (12 to the inch), and 168 in. of surface is contained in these four pairs of rolls running at 500 r.p.m. with a differential of 2½ to 1. This particular system is called the first break rolls, five breaks being used in this mill to reduce the wheat to bran. Figured on a yield of 4 bushels and 16 lb. per barrel of all grades of flour, 702 bushels of wheat per hour pass through these first break roller mills. On the first break the wheat is broken down so as to disintegrate the inside of the kernel into granules called semolina or more commonly termed middlings. It is scalped on a universal bolter and the tailings that pass over 16 wire tail to the second reduction on two double stands of 10 by 42 roller mills corrugated 14 to the inch and scalped over 18 wire; the tail of the scalping of the second break passes to the third break roll corrugated 16 to the inch and scalped over 20 wire; the tail of the scalping of the third break passes to the fourth break rolls corrugated 20 to the inch and scalped over 24 wire; the tail going to the fifth break rolls

corrugated 24 to the inch. The fifth break is scalped on reels, clothed with 30 wire, the tail of these reels being bran and dusted on bran dusters. On each of these breaks there are six different separations of middlings taken off and the residue being flour is dressed separately.

46 Of the five grades of middlings thus separated, the coarse scalped over 28 wire contain and are mingled with small particles of bran and the germ of the wheat, each separation being finer until the last separation scalped over a No. 9 silk contains very fine particles of bran. Each of these grades of middlings is sent to separate purifiers.

47 The operation of the purifiers is to remove the fluff and dust and tail over the coarser or branny particles called tailings. The siftings of the purifiers are reduced on smooth rolls by a gradual reduction; the coarse middlings are reduced so as to disintegrate the bran particles, the starch cells and germ, the semolina being again reduced to flour; the tailings are repurified and further reduced on smooth rolls and treated by several reductions as with the coarse middlings.

48 In all there are 19 reductions on smooth roller mills, the separations required to eliminate the germ, linings of the starch cells, fine bran called shorts and the bran, being very elaborate and necessitating exact judgment in selecting the proper numbers of wire or silk and skill in the art of grinding to accomplish the proper results.

49 The fine silk used for bolting the flour is manufactured almost exclusively in Switzerland by weavers on hand looms in their own homes. Great perfection in the evenness of the meshes is obtained, as fine as 200 meshes to the inch being made.

50 It is not possible to give in this paper more than a general outline of the process of the art of milling by gradual reduction, but the progress in the mechanical construction of a modern flour mill, which has by no means reached perfection either mechanically or in the art, can only be illustrated. Continual improvements are being made and one idea brings out another.

A NEW ANALYSIS OF THE CYLINDER PERFORMANCE OF RECIPROCATING ENGINES

By J. Paul Clayton

A PREFATORY STATEMENT

Early students in the field of thermodynamics gave generous attention to a study of the steam-engine indicator diagram. Attempts to deduce a law which would connect the form of the expansion curve of such diagrams with other factors affecting engine performance have, however, always failed, and in recent years studies involving the precise form of such curves have appeared unprofitable. It has remained for Mr. Clayton to discover the key which reveals the hidden relationships. The methods he has employed are so simple that they may be readily understood even by the casual reader. His conclusions are well sustained and are of sufficient significance to advance by a long step forward our understanding of the steam-engine problem.

Mr. Clayton's researches have been made under the auspices of the Engineering Experiment Station of the University of Illinois, and the results which he presents herewith will in due time be published in more complete form as a bulletin of the station.

W. F. M. Goss

ABSTRACT OF PAPER

Our knowledge of the cylinder performance of reciprocating engines is obtained almost entirely from indicator diagrams. These diagrams provide a measure of the work performed, thus enabling the efficiency or economy of the engine to be determined; they also provide an aid for setting valves, and furnish the basis in steam cylinders for applying Hirn's analysis, for measuring the initial condensation, and for finding the diagram factor for the purposes of design. It has been generally thought by engineers that the evidence contained in the diagram was limited only to these and minor uses.

The investigation described in this paper has disclosed the fact that the indicator diagram contains in itself the evidence necessary for an almost complete analysis of cylinder performance, the results of which have not heretofore been considered possible.

In obtaining these results the diagram has been transferred to logarithmic cross-section paper and thus a figure has been drawn which will be called a logarithmic diagram. By the aid of this diagram it has been found that the expansion and compression curves of all elastic media used in practise obey substantially the polytropic law $PV^n=C$. From this fact there have been developed rational methods of approximating the clearance of a cylinder, of closely

locating the cyclic events, and of detecting moderate leakage with the engine in normal operation.

It has been discovered that the value of n in the law $PV^n = C$ is controlled directly in steam cylinders by the value of the quality of the steam mixture at cut-off, called X_c, and that the relation of X_c and n is practically independent of cylinder size and of engine speed for the same class of engine. This fact enables us to determine the actual amount of steam and water present in a cylinder at cut-off from the experimentally determined relations of X_c and n, and thus to obtain the actual steam consumed from the diagram.

The paper contains an exposition of the graphical methods employed, charts giving the relations of X_c and n for determining the steam consumption from the diagram, and examples of typical logarithmic diagrams.

A NEW ANALYSIS OF THE CYLINDER PERFORMANCE OF RECIPROCATING ENGINES

By J. Paul Clayton, Urbana, Ill.

Junior Member of the Society

The investigation described in this paper is the result of an extensive analytical and experimental study of the forms of the expansion and compression curves which occur in indicator diagrams. From this study has been developed a new and very complete analysis of cylinder performance for reciprocating engines using any elastic fluid for the working medium.

2 The analytical study was carried on by transferring the indicator diagram to logarithmic cross-section paper and thus drawing a figure which will be called a logarithmic diagram. It is well known that the equation of the polytropic curve $PV^n = C$ becomes a straight line when plotted on logarithmic cross-section paper. Conversely, when the expansion or compression curve of an indicator diagram becomes a straight line in the logarithmic diagram, then the curve is of the form $PV^n = C$, the value of n being the slope of the line.

3 The logarithmic diagram is more useful for analysis than any other form of diagram because of the natural limitations of the human mind. We do not possess the power to distinguish between curves, but are able, however, to see clearly the differences in these curves after they have been transformed into straight lines, which fact alone makes these new methods of analysis possible. We are now enabled in their straight-line form to comprehend curves which we have always seen, but could not distinguish one from the other in their original form.

4 By means of the logarithmic diagram it has been found that, free from certain abnormal influences, expansion or compression of an elastic medium takes place in the cylinders of reciprocating engines substantially according to the law $PV^n = C$.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

5 From the fact that the law $PV^n = C$ holds for expansion and compression curves from practice, there have been developed rational methods of approximating the clearance volume, of closely locating the cyclic events, and of detecting moderate leakage when the engine is in regular operation. These methods apply, however, only to those indicator diagrams which are taken from the cylinders of reciprocating engines using any elastic fluid for the working medium and having as a part of the cycle an expansion or compression of the medium.

6 It has been discovered that the value of n for the expansion curves of steam diagrams bears a definite relation in any given cylinder to the proportion of the total weight of steam mixture which was present as steam at cut-off. This proportion or quality will be called X_c in this investigation, and its value will be expressed in decimal parts of unity. The relation of the value of n to the value of X_c for the same class of cylinder as regards jacketing has been found to be practically independent of engine speed and of cylinder size.

7 The practical significance of finding this relation is that there is now available an accurate method of approximating the value of X_c and therefore the actual weight of steam and water present at cut-off from the indicator diagram alone.

8 It is believed, after working with the new methods of analysis, that the existing methods are in a very crude state, and that many of the deductions made from them are without foundation or meaning.

9 Preliminary to the investigation, an examination was made of the nature and form of the expansion and compression curves from a large number of steam engines, by the aid of the logarithmic diagram.

10 Values of n in the equation expressing the law $PV^n = C$, however, exhibited a large range of variation, the range being from 0.70 to 1.34. The engines from which the values were obtained differed in type, size, speed, steam pressure, ratio of expansion and back pressure. Obviously, comparisons could not be made of these examples because of the number and magnitude of the variables.

11 Indicator diagrams taken from the same cylinder with different cut-off positions showed that the value of n was higher as the cut-off was lengthened. There was a large variation in the value of n where the conditions of cylinder size, speed, steam pressure and steam distribution were the same. The only variable shown by the diagrams was length of the cut-off. After considerable study, it was

decided that there might be some relation in any one cylinder between the value of n for the expansion curve and the value of X_c, as the value of X_c was known to be higher as the length of cut-off increased. One fact that seemed to confirm this hypothesis was that, with superheated steam (under the same general conditions, except the kind of steam used), when the value of X_c is high, the value of n for expansion is always much higher than with saturated steam. The only important variable between the use of saturated and superheated steam to account for the change in the value of n was the quality of the steam mixture at cut-off, or the value of X_c.

12 All cases of engines examined using superheated steam at normal cut-off showed n to be higher than 1.0, and as high as 1.34; and all cases of small engines using saturated steam showed n to be lower than 1.0 and as low as 0.70. These facts led to the conclusion that the value of X_c was the most important single factor in the accompanying value of n. Tests were therefore planned in which the effort was made to vary the value of X_c between the widest practicable limits.

LABORATORY TESTS

13 An outline of these tests will first be given, with a synopsis of the method of analysis used, after which the application of the analysis to indicator diagrams will be given for the purpose of determining cylinder performance.

14 A single-cylinder, long-range cut-off, 12-in. by 24-in., Corliss engine, located in the mechanical engineering laboratory of the University of Illinois, was selected for the tests. A Corliss engine was selected because of the fact that in this type all the steam used passes through the cylinder.

15 It was planned to observe the effect upon the value of n of varying the value of X_c under different conditions of pressure and speed; n being the exponent in the equation $PV^n=C$ for the expansion curve of an indicator diagram, and X_c the quality of the steam at cut-off. The value of X_c was varied through a large range by the use of saturated and superheated steam, in conjunction with different lengths of cut-off under the same conditions of pressure and speed. The values of X_c obtained ranged from 0.50 to 0.90, covering the range usually found in practice with the type of engine used.

16 The values of n for the expansion curves were obtained by means of the logarithmic diagram explained in detail in the Appendix. The value of X_c given in the log is the average of the results

obtained from one set of head-end and crank-end diagrams for each test. The unit of measurement, therefore, was the revolution, as the values of X_c for the head and crank ends cannot be measured separately when one exhaust pipe is used for both ends of the cylinder. The value of n given for one test is the average of the separate values from the expansion curves of the head-end and crank-end diagrams, taken from the set of diagrams already mentioned.

17 Seventy-four tests in 16 series were run. Of this number, 60 tests in 14 series were selected as fulfilling the requirements decided upon to give reliable data. Each series consisted of four to five separate tests, differing from each other only in the length of cut-off, with the same conditions of pressure and speed. All tests were run with the steam exhausting from the cylinder at about atmospheric pressure into a surface condenser. The length of cut-off was varied in nearly uniform steps from about 5 per cent to 45 per cent of the length of the stroke, and was the means of varying the value of X_c when using either saturated or superheated steam.

18 The 14 series were divided into two divisions of seven series each; one division being run with saturated steam, and the other with steam superheated to 500 deg. fahr. at the superheater. Each division consisted of five series run at different gage pressures at constant speed, and two series run at different speeds with constant pressure. The steam pressures used were 57.5, 76.5, 95, 113, and 132 lb. gage with the engine running at 120 r.p.m. The other speeds employed were 90 r.p.m. and 150 r.p.m. at the gage pressure of 113 lb. Each division, therefore, gave the effect of the use of five steam pressures at constant speed, and three speeds at constant pressure.

19 The governor change-speed device was always set to give the desired speed with the engine running at no-load. As the load was increased, the speed decreased through the action of the governor in about the same proportion for all initial speeds. Whenever speed is mentioned, the no-load speed is the one referred to, the exact speed for any one test being given in the general log.

20 The general log of the 29 tests run with saturated steam is given in Table 1. Table 2 contains the results of the 31 tests run with superheated steam. Table 3 gives the averages of similar series, called groups, run at the same pressure and speed, with both saturated and superheated steam. For any one group of the two series of tests, as has already been pointed out, the only variables are the length of cut-off and the value of X_c.

TABLE 1 GENERAL LOG. TESTS WITH SATURATED STEAM

Series	Number of Test	Pressure Lb. Per Sq. Inch				Revolutions per Hour	Weight of Condensate per Hour, lb.	Weight of Condensate per Revolution, lb.	Lb. of Steam per Revolution shown by Indicator at Cut-Off	Lb. of Compression saved per Revolution by Indicator	Lb. of Steam Mixture Actually present per Revolution	Quality of Steam Mixture at Cut-Off, Parts of Unity	Absolute Pressure at Cut-Off, Lb.	Average Value of *n* from Expansion Curves	Cut-Off, Per Cent of Stroke	Average Absolute Pressure at Cut-Off for Series, Lb
		At Throttle by Gage	Barometer	Absolute Pressure at Throttle	Average Absolute Pressure of Series at Throttle											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
I	2	57.8	14.3	72.1	....	6428	1054	0.1640	0.0929	0.0248	0.1888	0.492	60.3	0.926	14.6	....
	3	57.3	14.2	71.5	71.3	6100	1104.5	0.1811	0.1037	0.0221	0.2032	0.510	61.3	0.882	16.5	60.6
	4	55.8	14.5	70.3	....	6302	2010	0.3189	0.2099	0.0276	0.3465	0.606	60.2	0.961	41.2	....
II	6	77.0	14.3	91.3	....	6846	1010	0.1475	0.0846	0.0235	0.1710	0.495	76.8	0.927	8.1	....
	7	76.7	14.2	90.9	90.5	6440	1384	0.2149	0.1281	0.0230	0.2379	0.539	80.2	0.895	15.7	77.9
	8	75.6	14.5	90.1	....	6640	2104	0.3168	0.2089	0.0253	0.3421	0.610	77.4	0.949	30.9	....
	9	75.0	14.5	89.5	....	6282	2559	0.4073	0.2727	0.0260	0.4333	0.629	77.4	0.950	42.6	....
IV	15	95.8	14.3	110.1	....	6940	1048	0.1510	0.0903	0.0236	0.1746	0.517	95.6	0.910	6.1	....
	16	96.0	14.2	110.2	....	6510	1530	0.2350	0.1462	0.0226	0.2756	0.531	95.6	0.887	14.6	....
	17	94.9	14.2	109.1	109.1	6432	1584	0.2462	0.1533	0.0233	0.2695	0.569	96.2	0.914	15.5	95.3
	18	94.5	14.4	108.9	....	6750	2298	0.3404	0.2145	0.0246	0.3650	0.588	92.5	0.996	25.4	....
	19	93.6	14.4	108.0	....	6410	2758	0.4302	0.2952	0.0263	0.4565	0.647	95.6	1.002	37.0	....
	20	94.0	14.4	108.4	....	5958	3008	0.5048	0.3484	0.0248	0.5296	0.658	96.1	0.963	44.3	....
V	22	114.6	14.3	128.9	....	7046	1030	0.1461	0.0907	0.0239	0.1700	0.533	105.5	0.835	4.8	....
	23	113.7	14.2	127.9	127.7	6688	1566	0.2341	0.1445	0.0240	0.2581	0.560	110.0	0.944	11.3	109.4
	24	113.6	14.2	127.8	....	6466	1738	0.2687	0.1776	0.0227	0.2914	0.610	109.1	0.940	15.7	....
	25	112.0	14.2	126.2	....	6736	2664	0.3954	0.2708	0.0253	0.4207	0.644	113.0	1.004	27.3	....
VI	27	131.9	14.3	146.2	....	7086	986	0.1391	0.0941	0.0240	0.1631	0.576	126.7	0.946	3.7	....
	28	133.2	14.2	147.4	....	6862	1466	0.2136	0.1426	0.0231	0.2367	0.602	130.8	0.950	8.3	....
	29	132.0	14.2	146.2	146.2	6306	2000	0.3172	0.2050	0.0220	0.3392	0.604	130.0	1.006	16.4	129.4
	30	130.8	14.2	145.0	....	6840	2796	0.4087	0.2760	0.0256	0.4343	0.635	128.9	1.008	24.9	....
	31	132.0	14.4	146.4	....	6138	3276	0.5337	0.3762	0.0269	0.5606	0.671	130.6	1.010	35.3	....
VII	32	113.9	14.4	128.3	....	5258	1025	0.1949	0.0909	0.0251	0.2200	0.413	112.1	0.854	4.9	....
	33	113.9	14.4	128.3	128.4	5102	1585	0.3106	0.1641	0.0242	0.3348	0.490	113.2	0.932	12.8	113.7
	34	114.1	14.4	128.5	....	4940	2090	0.4230	0.2402	0.0246	0.4476	0.537	115.7	0.930	23.2	....
VIII	36	113.3	14.4	127.7	....	8772	1616	0.1842	0.1136	0.0260	0.2102	0.540	108.4	0.927	7.7	....
	37	114.2	14.4	128.6	127.9	8518	2554	0.2998	0.1990	0.0254	0.3252	0.612	110.3	0.964	19.7	110.3
	38	112.8	14.4	127.2	....	8182.5	3520	0.4302	0.3080	0.0256	0.4558	0.676	110.1	1.045	34.4	....
	39	113.5	14.4	127.9	....	7625	4142.5	0.5433	0.3968	0.0259	0.5692	0.697	112.2	1.016	46.0	....

TABLE 2 GENERAL LOG. TESTS WITH SUPERHEATED STEAM

Series	Number of Test	Pressure Lb. Per Sq. Inch				Revolutions per Hour	Weight of Condensate per Hour, Lb.	Weight of Condensate per Revolution, Lb.	Lb. of Steam per Revolution shown by Indicator at Cut-off	Lb. of Compression saved per Revolution by Indicator	Lb. of Steam Mixture Actually present per Revolution	Quality of Steam Mixture at Cut-Off, Parts of Unity	Absolute Pressure at Cut-Off, Lb.	Average Value of *n* from Expansion Curves	Cut-Off, Per Cent of Stroke	Average Absolute Pressure at Cut-Off for Series, Lb.
		At Throttle by Gage	Barometer	Absolute Pressure at Throttle	Average Absolute Pressure of Series at Throttle											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
IX	40	59.5	14.5	74.0	....	7040	815	0.1158	0.0838	0.0232	0.1390	0.602	61.2	0.904	11.7	....
	41	60.5	14.5	75.0	73.4	6856	1058	0.1543	0.1235	0.0239	0.1782	0.693	61.6	1.053	21.6	61.1
	42	57.7	14.5	72.2	....	6522	1288	0.1975	0.1738	0.0228	0.2203	0.788	60.6	1.114	32.0	....
	43	57.8	14.5	72.3	....	6262	1396	0.2229	0.2110	0.0227	0.2456	0.859	60.8	1.144	41.3	....
X	44	76.1	14.5	90.6	....	6655	1201.7	0.1806	0.1106	0.0246	0.2052	0.539	79.2	0.951	12.4	....
	45	77.4	14.5	91.9	91.0	6550	1294	0.1976	0.1342	0.0250	0.2226	0.603	79.2	0.957	16.5	78.5
	46	76.3	14.5	90.8	....	6290	1455	0.2313	0.1910	0.0230	0.2543	0.751	77.4	1.105	27.6	....
	47	76.0	14.5	90.5	....	5908	1822	0.3084	0.2720	0.0226	0.3310	0.822	78.0	1.112	41.5	....
XI	48	94.3	14.5	108.8	....	7112	822	0.1156	0.0877	0.0228	0.1384	0.634	92.8	0.924	6.1	....
	49	93.0	14.5	107.5	....	6936	1270	0.1831	0.1311	0.0234	0.2065	0.635	90.7	0.982	13.3	....
	50	95.5	14.5	110.0	109.0	6682	1660	0.2484	0.2040	0.0226	0.2710	0.753	97.1	1.040	22.3	94.1
	51	94.7	14.4	109.1	....	6500	1780	0.2738	0.2479	0.0220	0.2958	0.838	96.4	1.116	28.8	....
	52	95.1	14.4	109.5	....	6240	2072	0.3321	0.2821	0.0226	0.3547	0.796	93.6	1.001	39.2	....
XII	53	115.2	14.4	129.6	....	7100	914	0.1287	0.0972	0.0224	0.1511	0.642	111.5	0.991	5.1	....
	54	114.3	14.4	128.7	....	6932	1380	0.1991	0.1561	0.0225	0.2216	0.705	109.0	0.990	13.0	....
	55	114.1	14.4	128.5	128.4	6662	1906	0.2861	0.2419	0.0226	0.3087	0.783	111.7	1.032	22.9	111.0
	56	114.1	14.3	128.4	....	6326	2315	0.3660	0.3230	0.0219	0.3879	0.833	111.5	1.140	35.1	....
	57	112.3	14.5	126.8	....	5940	2350	0.3956	0.3709	0.0228	0.4184	0.886	111.5	1.209	40.3	....
XIV	61	132.5	14.3	146.8	....	7136	922	0.1292	0.0935	0.0228	0.1520	0.615	127.7	0.939	3.2	....
	62	128.0	14.3	142.3	....	7010	1384	0.1974	0.1553	0.0229	0.2203	0.715	123.6	0.969	11.0	....
	63	131.3	14.3	145.6	145.4	6810	1789	0.2627	0.2331	0.0228	0.2855	0.817	131.0	1.074	18.1	128.5
	64	131.0	14.3	145.3	....	6602	2171	0.3288	0.3113	0.0222	0.3510	0.887	130.5	1.190	26.9	....
	65	132.6	14.5	147.1	....	6088	2640	0.4336	0.3988	0.0230	0.4566	0.873	129.5	1.165	37.1	....
XV	66	114.8	14.5	129.3	....	5322	808	0.1518	0.0950	0.0220	0.1738	0.546	112.3	0.948	4.6	....
	67	114.2	14.5	128.7	128.0	5212	1218	0.2337	0.1540	0.0222	0.2559	0.602	111.1	0.941	12.4	111.7
	68	112.3	14.5	126.8	....	5018	1574	0.3137	0.2356	0.0226	0.3363	0.700	110.7	1.013	23.1	....
	69	112.7	14.5	127.2	....	4817	1809	0.3755	0.3078	0.0217	0.3972	0.774	112.5	1.148	32.0	....
XVI	71	112.8	14.5	127.3	....	8700	1512	0.1738	0.1447	0.0249	0.1987	0.729	108.0	1.093	12.3	....
	72	111.8	14.5	126.3	126.9	8438	2018	0.2392	0.2080	0.0257	0.2649	0.786	109.0	1.091	20.5	108.3
	73	112.2	14.5	126.7	....	8084	2458	0.3041	0.2970	0.0236	0.3277	0.907	107.2	1.213	32.4	....
	74	112.6	14.5	127.1	....	7494	3110	0.4150	0.4135	0.0237	0.4387	0.943	108.8	1.234	46.9	....

TABLE 3 LOG OF GROUP AVERAGES

Group	Series	Number of Tests Inclusive	Pressure, Lb. per Sq. In.			Absolute Pressure from Indicator Diagram, Lb. per Sq. In.					Specific Volume of Steam at Pressure Adopted	Number of Tests in Series	Number of Tests in Group	Number of Diagrams Analyzed	Average Quality of Steam Mixture at Cut-Off from Tests in Group, Parts of Unity	Average Value of *n* from Tests in Group
			Average Absolute Pressure at Throttle by Gage	Average Absolute Pressure of Group	Difference from Group Average of Next Lower Pressure	Average at Cut-Off	Average of Group	Difference from Group Average of Next Lower Pressure	Drop in Pressure, Throttle to Cut-Off	Pressure Adopted to find Quality of Steam Mixture at Cut-Off						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	I	2–4	71.3	72.4	...	60.6	60.9		11.5	61.0	7.06	3	7	14	0.6500	0.998
	IX	40–43	73.4	...	...	61.1	...	...	...	...	...	4	...	...	...	...
B	II	6–9	90.5	90.8	18.4	77.9	78.2	17.3	12.6	78.0	5.60	4	8	16	0.6235	0.981
	X	44–47	91.0	...	...	78.5	...	...	...	...	...	4	...	...	...	...
C	IV	15–20	109.1	109.1	18.3	95.3	94.7	16.5	14.4	95.0	4.65	6	11	22	0.6515	0.976
	XI	48–52	109.0	...	...	94.1	...	...		...	...	5	...	...	...	...
D	V	22–25	127.7	127.9	18.8	109.4	110.7	16.0	17.2	111.0	4.012	4	9	18	0.6885	1.010
E	VII	32–34	128.4	...	...	113.7	...	...		...	...	3	7	14	0.5803	0.967
F	VIII	36–39	127.9	...	...	110.3	...	...	...	...	...	4	8	16	0.7363	1.073
D	XII	53–57	128.4	...	...	111.0	...	...	...	...	...	5	...	...	...	...
E	XV	66–69	128.0	...	...	111.7	...	...	...	...	...	4	...	...	...	...
F	XVI	71–74	126.9	...	...	108.3	...	...	...	...	...	4	...	...	...	...
G	VI	27–31	146.2	145.8	17.9	129.4	129.0	18.3	16.8	129.0	3.478	5	10	20	0.6995	1.026
	XIV	61–65	145.4	...	...	128.5	...	...	...	...	...	5	...	...	...	...

21 *Values of n obtained under Different Conditions from the Same Engine Cylinder.* All the simultaneous values of X_c and n obtained from the 60 tests were plotted in Fig. 1. A study of this figure shows beyond question that as X_c increases in value, n increases also. The values all lie in a region which has a definite trend towards higher simultaneous values of X_c and n. Observing the general trend, it is seen that there is no exception to this general relation. No value of n below 1.00, for instance, is found for values of X_c above 0.80, and no value of n above 1.10 is found for values of X_c below 0.72.

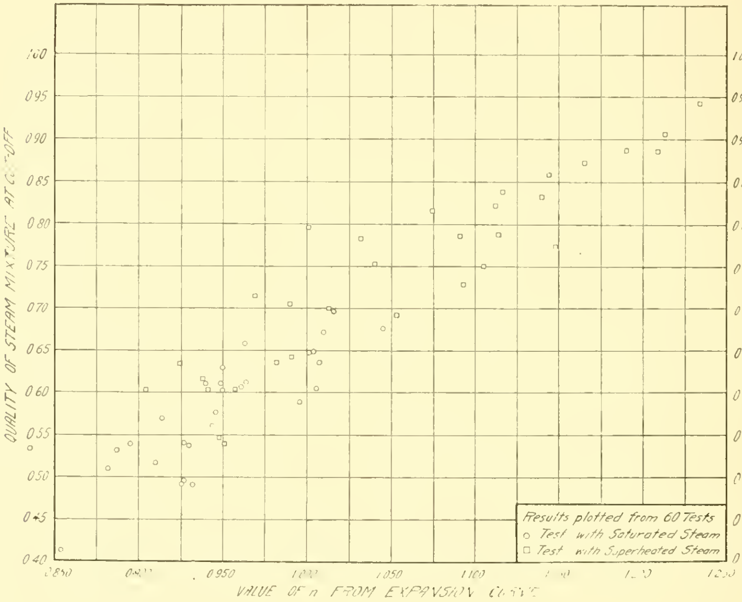


Fig. 1 General Relations between Quality at Cut-Off and the Value of n for Various Pressures and Speeds

22 It is also apparent that the points with long cut-off, obtained from saturated steam for given values of X_c and n, are in the same region occupied by the points with short cut-off obtained from superheated steam for the same given values of X_c and n. Examining the region of $n = 0.90 - 1.00$ and of $X_c = 0.50 - 0.70$, we see that the points obtained with long cut-off with saturated steam, and with short cut-off with superheated steam, lie indiscriminately together. This shows conclusively, in a general way, that the value of n is practically independent of the length of cut-off, even though this

length may vary from 5 per cent to 45 per cent, and that n depends solely on the value of X_c, the only other variable.

23 The points shown in Fig. 1 occupy a relatively wide region until they are separated into the various groups of similar pressures and speeds.

24 The points for each group were plotted separately, and separate curves were determined for each condition. From preliminary plotting, the relations between n and X_c were found to be expressed

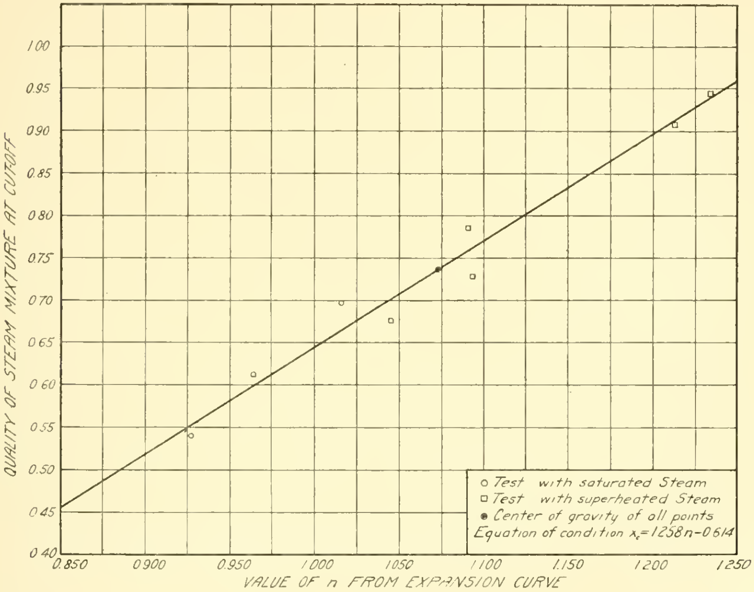


FIG. 2 RELATION OF QUALITY AND THE VALUE OF n FOR TESTS RUN AT 111 LB. ABSOLUTE PRESSURE OF CUT-OFF AND 150 R.P.M.

closer by straight lines than by any other family of curves. The method used to draw these lines will be given for group F, which includes series VIII, with four tests, and series XVI with four tests. This group is shown in Fig. 2. All points were given equal weight. The average of all the coördinates, or the "center of gravity" was found and the conditions imposed that the line pass through this center as an axis, and that the slope be determined by the position of the points. The points in group F were divided into four logical pairs or groupings, and the center of gravity found for each grouping. The line was then drawn as shown. Where points were located so that a logical grouping was in doubt, various groupings were made, and each given weight in determining the slope.

25 The equation of the curve selected is

$$X_c = 1.258\, n - 0.614$$

The average deviation of the points from this line is 2.6 per cent (measured from the zero of X_c) and the maximum deviation is 4.6 per cent. This average deviation, 2.6 per cent, is smaller than that for most of the groups. The straight line, in most cases, represents the points found as close as any other curve that could be employed, and has the merit of simplifying greatly the subsequent use made of the relations for the different groups.

26 The values of n for group F were also plotted to the various accompanying cut-off positions at which each test was run. This is shown in Fig. 3. The points in Fig. 3 show that for each initial condition of steam the value of n increased as the cut-off was lengthened, and that with any given cut-off different values of n were obtained according as saturated or superheated steam was used. Thus at a cut-off of 15 per cent, the value of n obtained is 0.950 with saturated steam, and 1.084 with superheated steam. The only variable present in these two cases is X_c, the value of which is higher with superheated steam than with saturated steam. A definite relation between n and the length of cut-off occurs only when a given cut-off is accompanied by the same value of X_c, that is, the value of n bears a direct relation to X_c but not to cut-off. Fig. 3 taken in conjunction with Fig. 2 proves that the value of n depends directly only upon the value of X_c, and that the relation of n and X_c is practically independent of the length of cut-off within the limits of the tests.

27 *Effect of Varying the Steam Pressure at Constant Speed.* The relations of X_c and n were determined separately for all groups by the method outlined for Fig. 2. The lines for the five pressures used, comprising the results of groups *A*, *B*, *C*, *D* and *G*, were replotted as shown in Fig. 4. This figure also contains other curves that are discussed in Paragraph 38. The lines shown give the relations of X_c and n for various absolute pressures at cut-off, all obtained with a speed of 120 r.p.m.

28 These curves were then examined to find the effect of varying the absolute pressure at cut-off (designated as p) on the relations of X_c and n. In Fig. 4, the constant pressure curves were intercepted at constant values of n, and the coördinates of X_c and p for the points of intersection plotted in Fig. 5. This process was repeated at intervals of 0.05 for the values of n from 0.850 to 1.250. The

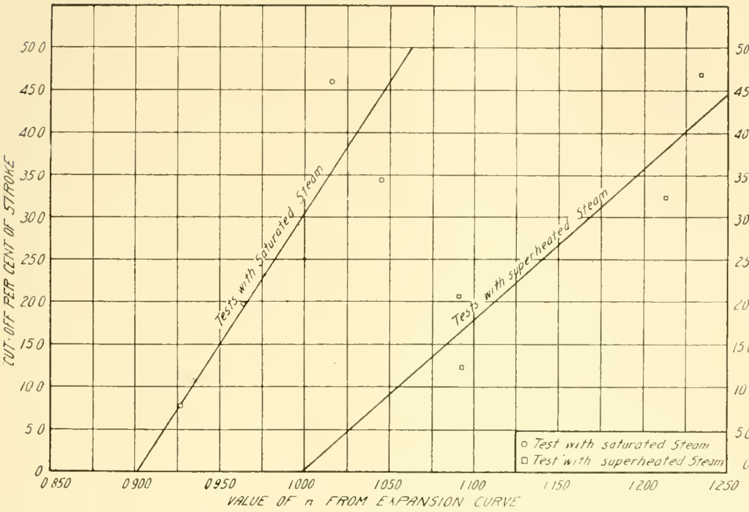


FIG. 3 RELATIONS OF PER CENT OF CUT-OFF AND THE VALUE OF *n* FOR TESTS RUN AT 111 LB. ABSOLUTE PRESSURE AT CUT-OFF AND 150 R.P.M.

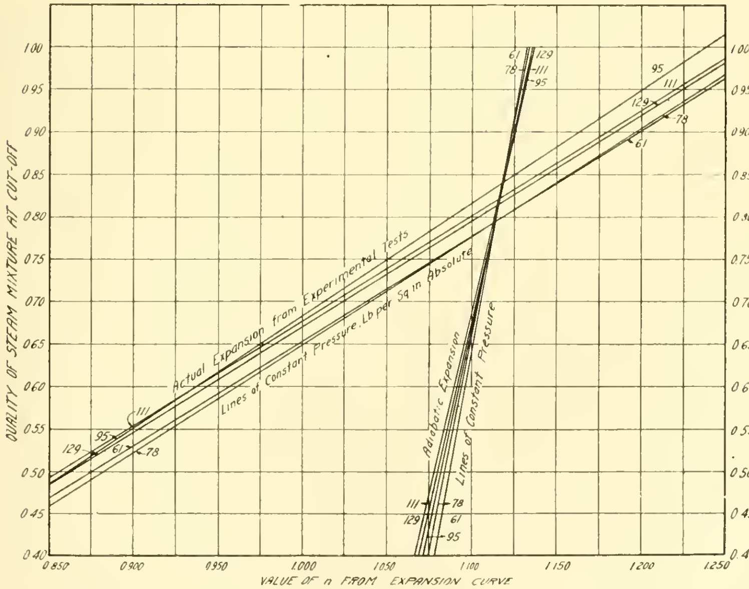


FIG. 4 RELATIONS AT CUT-OFF, BETWEEN QUALITY AND THE VALUE OF *n* FOR VARIOUS PRESSURES AT CONSTANT SPEED

resulting points did not give smooth curves, but, after considerable study and trial, curves were adopted as shown.

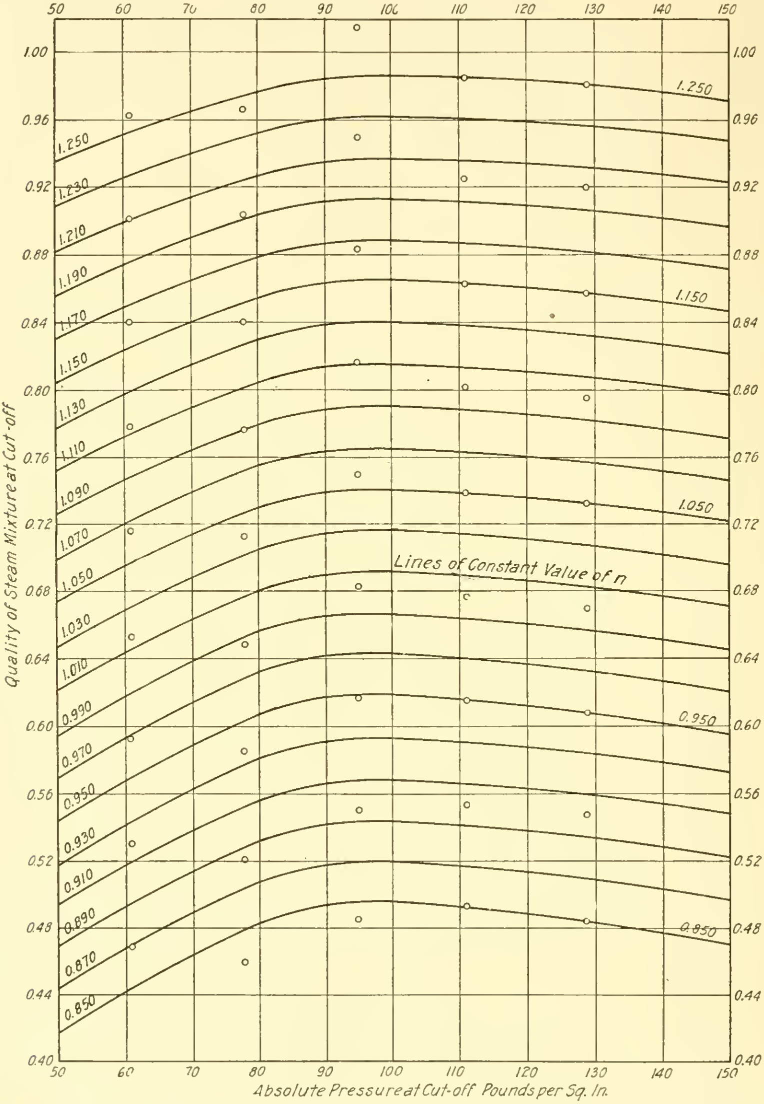


Fig. 5 The Relation at Cut-Off, between Quality and Pressure for Constant Values of n from Expansion Curve

29 This procedure gave a series of relations between X_c and p for constant values of n. Since, however, the independent variables

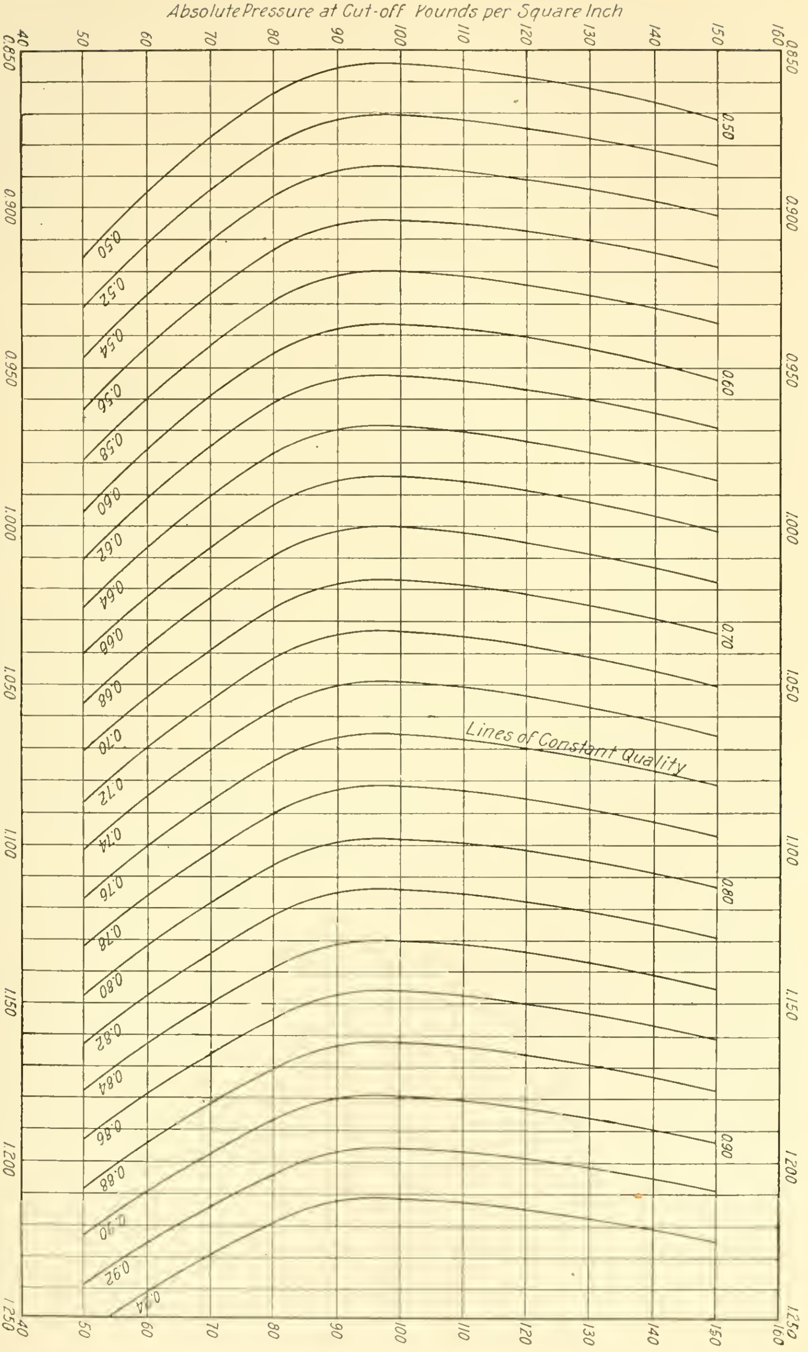


FIG. 6 THE RELATION BETWEEN PRESSURE AT CUT-OFF AND VALUES OF n FOR CONSTANT QUALITY AT CUT-OFF

in any actual curve under examination are n and p, the coördinates of the curves of Fig. 5 were changed so as to show the relations of n and p at constant values of X_c. These are shown in Fig. 6.

30 The effect of a change of pressure on the relations of X_c and n is not great between the limits of 75 to 150 lb. An approximate equation has been worked out, therefore, which represents the relations of X_c and n at an average pressure between the limits mentioned. The equation corresponds to the relations at 129 lb. and is of the form

$$X_c = 1.245\ n - 0.576$$

31 *Effect of Varying the Speed at Constant Pressure.* Groups D, E, and F were run at speeds of 120, 90, and 150 r.p.m., respectively, with the average cut-off pressure on the diagrams constant at 111 lb. absolute.

32 The regulation of the governor was very poor, there being about a 10 per cent drop in speed from no-load to full load. For this reason the relations of X_c and n with various speeds at constant pressure were affected by considerable variation of the speed itself for each group.

33 The relations for each group were found as already described, and the curves plotted in Fig. 7. The relation of speed (designated as s) and X_c for constant values of n was derived from Fig. 7, and is given in Fig. 8.

34 The apparent relations of X_c, s, and n, obtained by drawing a smooth curve through the three points obtained for each value of n, is not satisfactory owing to insufficient data and the change of the speed itself in the three groups due to poor regulation.

35 The drop in the speed, for one group, does not seriously affect, however, the relations of X_c and n for the various pressures at constant speed.

36 *Relation of the Value of n to the Quality of the Steam Mixture at Cut-Off.* From the evidence obtained from these tests, it may be stated positively that for any one engine running at a given pressure and speed, there is a definite relation between X_c and n which is practically independent of the cut-off position within the limits examined. This relation is apparently a linear one. It may also be stated that the relation of X_c and n is dependent, to some extent, on the absolute pressure at cut-off, and on the speed of the engine.

37 It remained to compare the relations of X_c and n for the engine tested with the relations for other engines. This comparison is made in Table 4.

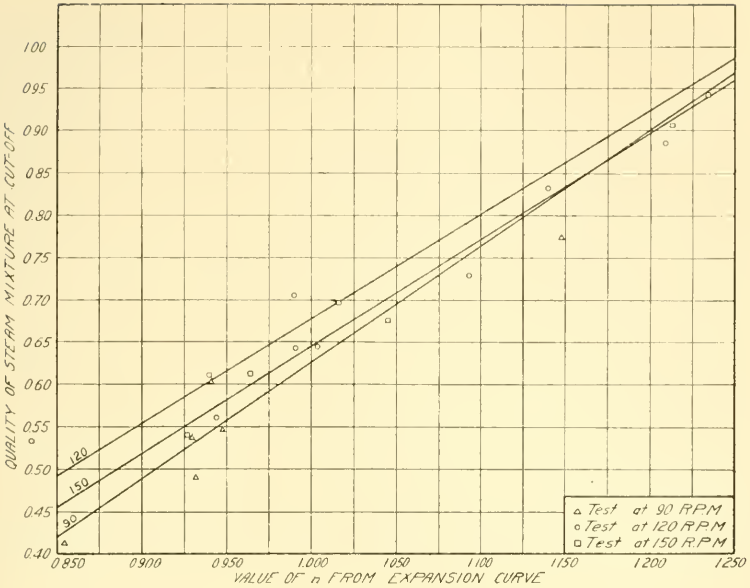


FIG. 7 RELATION OF QUALITY AT CUT-OFF AND THE VALUES OF n FOR VARIOUS SPEED OF THE CONSTANT CUT-OFF PRESSURE OF 111 LB.

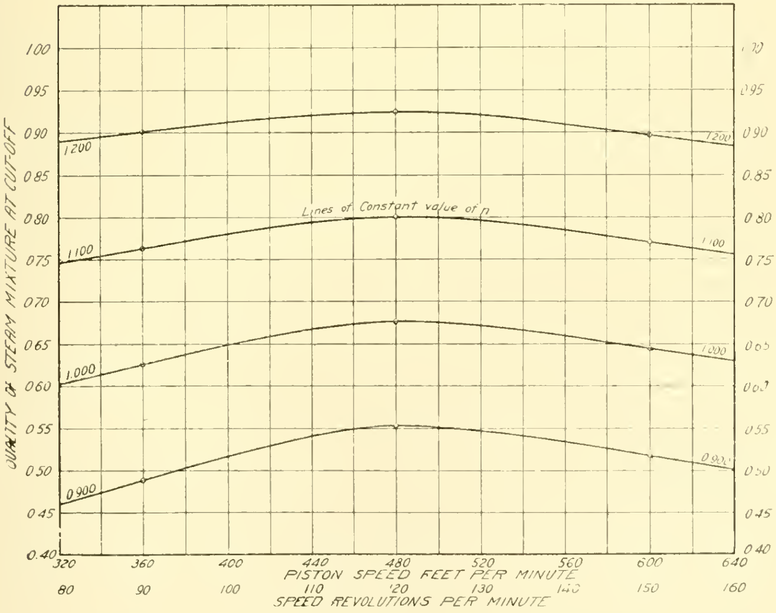


FIG. 8 RELATIONS, AT CUT-OFF, BETWEEN QUALITY AND SPEED FOR CONSTANT VALUES OF n AT CONSTANT PRESSURE

TABLE 4 APPROXIMATION OF THE ACTUAL STEAM CONSUMPTION FROM INDICATOR DIAGRAMS TAKEN FROM NON-JACKETED STEAM ENGINES

Number of Analysis	Class of Engine	Cylinder Dimensions, In.	Piston Rod Diameter, In.	Clearance, Per Cent of Piston Displacement	Actual Weight of Steam Passing through Cylinder, Lb. per Hour	Total I.H.P. Developed	Actual Steam per I.H.P-Hr., Lb.	Revolutions per Minute	Revolutions per Hour	Weight of Steam		
										Passing through Cylinder per Revolution, Lb.	Shown by Indicator at Cut-Off, Lb.	Retained in Compression per Revolution by Indicator, Lb.
1	2	3	4	5	6	7	8	9	10	11	12	13
		Simple Corliss, 2-Valve, and 4-Valve, Non-Condensing Engines										
101	Corliss, single cylinder	23 x60	3¼	2.5	8477	305.2	27.77	74.7	4482	1.890	1.666	0.130
102	Corliss, single cylinder	28½x59½	4	3.0	13070	506.5	25.80	64.8	3888	3.362	2.822	0.167
103	Corliss, single cylinder	26 3/16x48	3⅞	3.0	6742	232.3	29.03	64.7	3882	1.736	1.402	0.116
104	Double-valve, 2 cylinders	17 x24 2	2¾	2.0	7952	310.1	25.64	152.9	9174	0.8670	0.7290	0.0635
105	Four-valve, single cylinder	16⅝x32	2¾	4.0	1879	50.2	37.43	79.8	4788	0.3925	0.2732	0.0607
106*a*	Four-valve, single cylinder	10½x12	2	5.0	2353	97.9	24.04	263	15780	0.1491	0.1377	0.0242
106*b*	Same engine as 106*a*	....	...	....	1878	79.2	23.71	258	15480	0.1213	0.0959	0.0160
106*c*	Same engine as 106*a*	....	...	....	997	41.7	23.90	260	15600	0.0639	0.0537	0.0260
106*d*	Same engine as 106*a*	....	...	....	693	25.8	26.87	263	15780	0.0439	0.0402	0.0351
107	Corliss, 2 cylinders	16 x42	2¾	2.5	8873	342.43	25.91	84.9	5094	1.742	1.420	0.041
108*a*	Four-valve, single cylinder	18 x30	2⅝	5.0	4707	213.2	22.08	165.6	9936	0.4735	0.3890	0.0330
108*b*	Same engine as 108*a* (condensing)	....	...	....	6050.2	209.1	28.93	164.4	9864	0.6137	0.5657	0.0712
109	Corliss, 2 cylinders (1 condensing)	23 x60	3⅜	3.0	13187	615.1	21.44	61	3660	3.602	3.140	0.080
110	Corliss, 1 cylinder (1 end condensing)	34 2x60	4⅞	3.0	11613	523.43	22.19	53.3	3198	3.633	2.835	0.093
111	Corliss, 2 cylinders (1 condensing)	28 x60	4	2.5	14295.7	562.1	25.43	60.27	3616.2	3.953	2.860	0.250
		Compound Condensing Engines—H.P. Cylinders										
151	Corliss cross-compound	20 x36x36	3	2.5	6740	433.5	15.00	75.83	4550	1.481	1.244	0.1012
152	Buckeye cross-compound	18¾x36x36	3½	4.3	8675	639.2	14.20	123.3	7398	1.173	1.023	0.1490
153	Corliss cross-compound	15x30⅛x30	2¾	4.0	2007	140.78	14.26	47.98	2879	0.6970	0.5492	0.0218
		Triple-Expansion Condensing Engines—I. P. Cylinders										
201	Corliss (slow-speed pumping engine)	24⅛x34x54x36	4½	2.10	4622	328.05	14.09	27.66	1659.6	2.787	1.432	0.031
		High-Speed Single-Valve, Non-Condensing Engines										
401	Piston valve, single cylinder	16 x16	2⅝	13.15	4820	184.6	26.35	253.4	15204	0.3196	0.3060	0.0948
402	Single valve, single cylinder	14½x13	2¼	10.0	1740	53.26	32.67	246	14760	0.1179	0.1197	0.0613
403	Single valve, single cylinder	14½x13	2¼	12.0	2018.6	61.7	32.71	248.4	14904	0.1353	0.1314	0.0594
		Simple Locomotive Engines										
451	Two cylinder slide valve	16 x24	2¾	H C R 7.44 7.98 L 7.34 7.63	7180	252.79	28.40	97.08	5824.8	1.232	1.0164	0.1947

	Weight of Steam				Approximation from Chart							Approximation from Equation $X_c = 1.245n - 0.576$							
								Weight of Steam							Weight of Steam				
Number of Analysis.	Mixture Actually Present per Revolution, Lb.	Quality of Steam Mixture at Cut-Off (X_c), Parts of Unity	Average Value of n from Expansion Curves	Absolute Pressure at Cut-Off, Lb. per Sq. In.	Value of X_c from Chart, Parts of Unity	Per Cent that the Value of X_c from Chart is Higher (+) or Lower (−) than Test Results	Total Weight of Steam Mixture Present per Revolution, Lb.	Passing through Cylinder per Revolution, Lb.	Passing through Cylinder per Hour, Lb.	Per I.H.P-hr., Lb.	Per Cent that Total Weight of Steam per Hour is Higher (+) or Lower (−) than Test Results	Value of X_c from Equation $X_c = 1.245n - 0.576$	Per Cent that the Value of X_c from Equation is Higher (+) or Lower (−) than Test Results	Total Weight of Steam Mixture present per Revolution, Lb.	Passing through Cylinder per Revolution, Lb.	Passing through Cylinder per Hour, Lb.	Per I.H.P-Hr., Lb.	Per Cent that Total Weight of Steam per Hour is Higher (+) or Lower (−) than Test Results	Method Giving Closer Approximation to Test Results, Chart (C), Equation (E)
1	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Simple Corliss, 2-Valve, and 4-Valve, Non-Condensing Engines																			
101	2.020	0.825	1.098	65	0.767	−7.0	2.172	2.042	9160	30.00	+8.1	0.790	−4.2	2.110	1.980	8880	29.18	+4.8	*E*
102	3.529	0.801	1.108	75	0.795	−0.7	3.551	3.384	13150	25.96	+0.7	0.804	+0.4	3.512	3.345	13000	25.57	−0.5	*E*
103	1.852	0.757	1.051	75	0.732	−3.3	1.915	1.799	6985	30.06	+3.6	0.733	−3.2	1.913	1.797	6980	30.02	+3.5	*E*
104	0.9305	0.784	1.131	70	0.816	+4.1	0.8935	0.8300	7615	24.53	−4.2	0.833	+6.3	0.8752	0.8117	7445	24.00	−6.4	*C*
105	0.4532	0.603	0.964	60	0.586	−2.8	0.4665	0.4058	1942	38.69	+3.3	0.624	+3.5	0.4381	0.3774	1807	36.00	−3.8	*C*
106*a*	0.1733	0.794	1.076	120	0.769	−3.1	0.1791	0.1549	2440	24.92	+3.7	0.764	−3.8	0.1802	0.1560	2461	25.15	+4.6	*C*
106*b*	0.1373	0.698	1.034	115	0.717	+2.7	0.1337	0.1177	1822	23.01	−3.0	0.711	+1.9	0.1349	0.1189	1840	23.22	−2.0	*E*
106*c*	0.0899	0.598	0.931	125	0.587	−1.8	0.0915	0.0655	1021	24.50	+2.4	0.583	−2.5	0.0921	0.0661	1031	24.72	+3.4	*C*
106*d*	0.0790	0.509	0.868	120	0.511	+0.4	0.0787	0.0436	688	26.68	−0.7	0.504	−1.0	0.0798	0.0447	705	27.32	+1.2	*C*
107	1.783	0.797	1.077	95	0.774	−2.9	1.835	1.794	9140	26.69	+3.0	0.765	−4.0	1.856	1.815	9245	27.00	+4.2	*C*
108*a*	0.5065	0.768	1.095	63	0.759	−1.2	0.5125	0.4795	4762	22.32	+1.2	0.788	+2.6	0.4937	0.4607	4577	21.45	−2.8	*C*
108*b*	0.6849	0.826	1.116	63	0.785	−5.0	0.7202	0.6490	6402	30.60	+5.8	0.814	−1.5	0.6947	0.6235	6150	29.40	+1.7	*E*
109	3.682	0.853	1.149	80	0.853	±0.0	3.682	3.602	13187	21.44	±0.0	0.854	+0.1	3.677	3.597	13160	21.40	−0.2	*C*
110	3.726	0.761	1.071	74	0.749	−1.6	3.785	3.692	11810	22.57	+1.7	0.758	−0.4	3.740	3.647	11655	22.28	+0.4	*E*
111	4.203	0.680	1.048	68	0.709	+4.3	4.033	3.783	13685	24.33	−4.3	0.729	+7.2	3.922	3.672	13280	23.62	−7.1	*C*
Compound Condensing Engines—H.P. Cylinders																			
151	1.582	0.786	1.079	100	0.777	−1.1	1.600	1.4988	6820	15.73	+1.2	0.767	−2.4	1.621	1.5198	6915	15.95	+2.6	*C*
152	1.322	0.774	1.060	120	0.749	−3.2	1.366	1.2170	9005	14.09	+3.8	0.744	−3.9	1.375	1.226	9070	14.19	+4.6	*C*
153	0.7188	0.764	1.047	130	0.728	−4.7	0.7542	0.7324	2109	14.97	+5.1	0.728	−4.7	0.7542	0.7324	2109	14.97	+5.1	*C* & *E*
Triple Expansion Condensing Engines—I P Cylinders																			
201	2.818	0.508	0.914	38.5	0.470	−7.5	3.048	3.017	5003	15.25	+8.2	0.562	+10.6	2.550	2.519	4180	12.74	−9.6	*C*
High-Speed Single Valve Non-Condensing Engines																			
401	0.4144	0.739	1.027	110	0.710	−3.9	0.4310	0.3362	5115	27.70	+6.1	0.703	−4.9	0.4352	0.3404	5178	28.02	+7.4	*C*
402	0.1792	0.668	0.970	85	0.637	−4.6	0.1879	0.1266	1870	35.10	+7.5	0.631	−5.5	0.1898	0.1285	1897	35.61	+9.0	*C*
403	0.1947	0.675	0.985	74	0.641	−5.0	0.2050	0.1456	2170	35.19	+7.5	0.650	−3.7	0.2021	0.1427	2128	34.48	+5.4	*E*
Simple Locomotive Engines																			
451	1.4267	0.711	1.003	100	0.683	−3.9	1.488	1.2933	7540	29.83	+5.0	0.673	−5.3	1.5110	1.3163	7675	30.38	+6.9	*C*

38 An investigation[1] of the value of k for adiabatic expansion shows that there is a relation between the initial quality X_1 and the value of k which, like the experimentally determined relation, is also a linear one. The adiabatic relations of X and k are plotted in Fig. 4 for the pressures used in the tests.

THE METHOD OF APPROXIMATING THE ACTUAL STEAM CONSUMPTION FROM INDICATOR DIAGRAMS

39 When indicator diagrams were first obtained from steam engines, loss from initial condensation was not suspected and it was believed that the steam consumption could be determined from the diagram at the point of cut-off. After the classic tests of Clark and Isherwood, however, the existence and amount of this initial condensation was revealed; but the great difference in the proportion that the initial condensation bears to the total weight of mixture present, either at cut-off or during the expansion, as found in different types and sizes of engines, has prevented any reliable determinations of the actual steam consumption by this method. The steam consumption computed from the diagram, when using saturated steam, is generally from 15 per cent to 50 per cent below the actual consumption.

40 The devising of an accurate method of measuring the actual weight of steam consumed from the diagram has therefore been regarded as impossible. Thurston[2] states that "the steam or water consumption of an engine cannot be exactly ascertained by the use of the indicator" for the reasons mentioned. Most of the other writers on the subject have expressed smilar views.

41 Methods of computing the weight or proportion of the initial condensation from the dimensions, type, and speed of the engine considered, as shown by the results of large numbers of tests, have been devised by many.[3] The results obtained from these methods have not been uniform, and do not agree closely enough with the test results to be used with confidence. Moreover, none of these methods is applicable when superheated steam is used. R. C. H.

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[1] Principles of Thermodynamics, G. A. Goodenough, p. 191.

[2] Engine and Boiler Trials, R. H. Thurston, p. 237.

[3] A Manual of the Steam Engine, R. H. Thurston, p. 517.
Engineer (London), Escher, 1882.
Relative Proportions of the Steam Engine, L. S. Marks, p. 206.
Proc. Inst. Mech. Engrs., October 1889.
Engineering, Bodmer, March 4, 1892, p. 299.
The Steam Engine, Cotterill, p. 339.

Heck[1] states that the steam consumption computed by the use of his formula should ordinarily show not more than 10 per cent difference from the test results.

42 *The Phenomena Occurring in the Cylinder.* The greatest source of loss in the cylinder is due primarily from practical considerations to the use of a metallic structure. The skin surface of this metal, which is a fairly good conductor of heat, must be heated once every cycle from the temperature acquired from contact with the exhaust steam, nearly up to the temperature of the admission steam, this heating being accomplished by the condensation of some of the incoming steam.

43 The amount of this condensation, measured as the proportion of the mixture present, varies with the size, valve design, relative roughness of the interior surface, temperature range, length of cut-off, speed, location of ports and port passages, quality of the steam supplied, and the jacketing and lagging. It can easily be seen, from the number and relative magnitude of these variables, that the computation of the weight of condensation, by means of a formula which will take these variables into account, can never be an accurate operation.

44 After many examinations into the cases of different types and sizes of engines, with non-jacketed cylinders in good order, and with pressure limits similar to those used with the tests, it has been found that while the initial condensation is subject to the action of ten or more variables, yet the value of n resulting from a given value of X_c is almost always substantially the same. A few of the applications showing this point will be found in Table 4. Here the cylinder sizes vary from $10\frac{1}{2}$ in. by 12 in. to 34.2 in. by 60 in., the speeds from 48 to 263 r.p.m., and the types include slow-speed Corliss, high-speed, and locomotive engines. The possibility of calculating accurately the weight of condensation in these different cases may be easily imagined.

45 The phenomena caused by the presence of the cylinder walls in the class of engines discussed have been found to be divided into two natural classes: those occurring before cut-off, and those occurring after cut-off.

46 The phenomena occurring before cut-off are controlled by the action of the ten or more variables already mentioned, and therefore are subject to all the variation that may occur in any individual case to be examined. For this reason any method of computing the

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[1] The Steam Engine, R. C. H. Heck, p. 119.

condensation accurately from the physical facts surrounding the case is open to objection. This method also cannot allow for the use of superheated steam, an increasingly important condition.

47 The phenomena occurring after cut-off are practically independent of all variables except X_c, and the initial pressure and speed. Of these variables, only the value of X_c and the initial pressure have proved to be of material importance in the applications made thus far.

48 This may be summed up by stating that the value of X_c, in any particular case, is subject to the action of many important variables, but that the relation of X_c and n is practically independent of these variables within the limits examined in this investigation.

49 *The Phenomena of Condensation and Re-Evaporation during Expansion.* When adiabatic expansion of initially dry saturated steam takes place, a part of the steam is condensed as the pressure is lowered, the condensed steam giving up its latent heat which is converted into work. When superheated steam is expanded adiabatically, the steam loses its superheat until saturation is reached, after which condensation takes place as in the case of initially dry steam.

50 When, however, the steam is initially composed of a large proportion of water, both being at the same temperature, adiabatic expansion may take place without additional condensation and may even be accompanied by re-evaporation. This fact is due to the large amount of heat contained in the water, a part of which flashes into steam as the pressure is lowered, thus supplying and neutralizing the loss of steam volume by condensation which takes place with steam initially dry. Adiabatic expansion is accompanied by condensation when the initial quality is above the value 0.50 at an initial pressure of 240 lb. per sq. in. absolute, but below the value of 0.50 it is accompanied by re-evaporation. An examination of the temperature entropy diagram for steam will show the values of the initial quality which form the line of demarcation of condensation and re-evaporation during the adiabatic change of state.

51 In the actual engine using saturated steam, as has already been pointed out, some of the incoming steam is condensed in warming up the skin surface of the cylinder walls to approximately the temperature of the incoming steam. When the admission of steam is cut off and expansion commences, the condensation, due to the presence of the cylinder walls, continues in general until, at some point during expansion, the water on the cylinder walls begins to re-

evaporate at such a rate that the weight of steam present at the end of expansion is greater than that which was present at cut-off.

52 To show the effects and extreme values of condensation and re-evaporation during expansion, there have been prepared in Table 5 two examples, using the average results of the tests run.

TABLE 5 CONDENSATION AND RE-EVAPORATION OF STEAM DURING EXPANSION

Example number	1	2
Initial quality, parts of unity	0.540	0.950
Pressures, Lb. per Sq. In. Absolute		
Initial	145.0	145.0
Final	20.0	20.0
Value of n in Equation $PV^n = C$		
Adiabatic expansion, from Table 20	1.082	1.133
Actual expansion in engine tested, from Fig. 6	0.900	1.230
Volume of Steam Present, Cu. Ft. (Volume of water neglected)		
Initial	1.00	1.00
Final, adiabatic expansion	6.24	5.75
Final, curve of constant steam weight	6.44	6.44
Final, actual expansion in engine tested	9.04	5.00
Weight of Steam Present, Lb.		
Initial, plus water	0.594	0.338
Initial, steam only	0.321	0.321
Final, adiabatic expansion	0.311	0.287
Final, curve of constant steam weight	0.321	0.321
Final, actual expansion in engine tested	0.450	0.249
Quality of Steam at Final Pressure, Parts of Unity		
Adiabatic expansion	0.524	0.849
Curve of constant steam weight	0.540	0.950
Actual expansion in engine tested	0.757	0.736
Condensation or Re-evaporation, Parts of Unity		
Apparent re-evaporation	0.217	
Real re-evaporation	0.233	
Apparent condensation		0.214
Real condensation		0.113

53 Example 1 is a condition which obtains in the engine tested when using saturated steam at about 140 lb. gage pressure with a length of cut-off of about 3 per cent. All values of the qualities mentioned are portions of the total weight of mixture in parts of unity. The value of X_c is 0.540, a low value, yet one which often obtains in small engines. If this steam were expanded adiabatically

to the back pressure, 20 lb. absolute, the resulting quality would be 0.524, giving a condensation of 0.016. The expansion which actually takes place in the engine tested under these conditions results in a final quality of 0.757, showing that the apparent re-evaporation from the value of X_c has been 0.217. However, the steam mixture in expanding *did* expand adiabatically in order to give up heat to work, but the actual or what might be called the gross expansion, was changed in character by the re-evaporation of a large proportion of the water present, due to the return of heat from the cylinder walls and the consequent flashing into steam of part of the water when the pressure and the temperature were lowered. The real re-evaporation, measured by its effect upon adiabatic expansion, has been the difference between 0.757 and 0.524 or 0.233.

54 The actual expansion in this case has been the result of two factors which worked simultaneously: adiabatic expansion and the return of heat from the cylinder walls to the mixture. The first factor, adiabatic expansion, as already explained, is itself the result of two neutralizing or opposing conditions, i. e., the condensation of initially dry steam during expansion, and the relatively smaller amount of re-evaporation of water initially in the mixture due to the liberation of its excess of heat when the pressure and temperature were lowered. The net result of the two conditions of this adiabatic expansion, however, was a condensation. The second factor is the large amount of re-evaporation due to the return of heat from the surface of the cylinder walls to the condensed steam, amounting in Example 1 to 0.233, or, roughly, there has been re-evaporated during expansion $\frac{1}{4}$ of the entire weight of mixture present.

55 Example 2 shows conditions which obtain in the engine tested when served with steam superheated about 125 deg. fahr. at about 140 lb. gage pressure, with a length of cut-off of about 45 per cent. The value of X_c is 0.950, a very high value for this class of engine. The quality after adiabatic expansion would be 0.849, a condensation of 0.101. Where values of X_c are as high as 0.950, however, no re-evaporation takes place in practice, but condensation continues throughout expansion. After expansion in the engine tested, the quality would be 0.736, showing much greater condensation than that due to adiabatic expansion alone. The apparent condensation has been 0.214, but the real condensation, measured by its effect upon adiabatic expansion, has been 0.113.

56 The actual expansion in Example 2, as in Example 1, has been

the result of two factors: adiabatic expansion and the further abstraction of heat during the whole expansion by the cylinder walls. Heat is abstracted during expansion by the cylinder in the engine tested at all values of X_c above 0.85, thus giving values of n higher than the adiabatic value k.

57 The phenomena of condensation and re-evaporation during expansion are the causes of the relations existing between X_c and n in the cylinders of steam engines. The two examples given show values obtained in extreme cases which illustrate very well the effect of X_c upon the character of the expansion, and therefore upon the value of n, and show the range of values that n assumes in one engine due to a change in the value of X_c.

58 *The Relation of X_c and n.* The relation of X_c and n, for the same engine, has been shown by the author's tests to be very definite under the same conditions of pressure and speed. This relation, or dependence of n upon X_c, however, is not seriously affected by changes of pressure and speed within the limits of the tests.

59 The ordinary speeds of similar types of engines, 70 to 120 r.p.m., do not affect the relation seriously enough to be taken into account when examining such cases, because of the twofold character of speed in its influence upon the action of the cylinder walls.

60 The engine experimented upon was operated at 120 r.p.m., and had a stroke of 2 ft. Other engines of this class run at speeds as low as 70 r.p.m., but have strokes of 5 or 6 ft. Cylinder condensation is not dependent upon rotative speed alone, but is also influenced by the piston speed, as determined by the length of the stroke. On account of different lengths of stroke, different engines cannot be compared on the basis of rotative speed. Thus while the small engine tested has a rotative speed of 120 r.p.m., its piston speed is only 480 ft. per min. In large engines, while the rotative speed may be only 70 r.p.m., yet, with strokes of 6 ft., the piston speed is 840 ft. per min. What the small engine gained by higher rotative speed, the large engine made up in a measure by higher piston speed.

61 After taking into account the two parts of which speed is composed, it is found that the speeds of stationary engines of the type tested are in substantially the same range. On account of this fact, only the results of the tests run at 120 r.p.m. have been used in the applications made at present.

62 The relation of X_c and n has been found to be practically independent of cylinder size. This statement is true for non-jacketed

cylinders and for pressures in the range examined. This is shown in a general way in the following discussion for saturated steam.

63 It appears, therefore, that this method of approximating the value of X_c at cut-off from experimentally determined relations, and thus accounting for the initial condensation, is upon much surer ground than any method of computing condensation from the physical facts surrounding the case. It approaches the problem from the side where the phenomena occurring are practically independent of all the variables mentioned. This fact adds greatly to the accuracy obtained, and with the applications given in Table 4 shows that an accurate and reliable method of approximating the actual steam consumed from the indicator diagram alone has been devised.

64 This method is free from several objections to which tests are open. It measures the consumption in one revolution, and is, therefore, practically measuring a *rate* instead of a *quantity*. The only data needed for an approximation are one set of indicator diagrams, taken simultaneously, the constants of size and clearance, and the speed of the engine tested. No interruption of any kind in the routine of a plant is caused, and the expense incurred is not to be compared with that of an equally accurate test. The method is accurate enough for almost all purposes except guarantee tests subject to bonus and forfeit contracts. In the case of locomotives on the road, it is the *only* possible method of approximating the steam consumption of the main engines, due to the use of steam by the air-pump, train-heating system, blower, generator sets, safety valves, whistle, blow-off valves, and leaks. The same is true of marine engines, where many auxiliaries are supplied with steam from the same boilers, and exhaust into the same surface condensers. The method is especially useful for non-condensing engines, where the boiler-feed measurement method is the only practicable one. Steam consumption may be obtained as often as is desired instead of probably once in an engine's life.

65 *Limitations.* The relations of X_c and n given in Fig. 6 are applicable, however, only to non-jacketed cylinders exhausting at very close to atmospheric pressure. When the back pressure is raised to 30 lb. absolute, for instance, there is a new series of relations existing for the same initial pressure, due to a different temperature range in the cylinder and the consequent alteration of the phenomena occurring after cut-off. Steam jackets also alter the phenomena occurring after cut-off, and therefore have to be examined separately for the relations of X_c and n.

66 Since this method rests entirely on the indicator diagram, great care must be observed in taking these diagrams. The indicator itself must be an accurate instrument in the best possible condition. The indicator connections must be short and direct. An extensive investigation by W. F. M. Goss [1] shows that the long and indirect pipe connections materially alter the form and character of the expansion curves. A correct reducing motion, free from lost motion, must be used so as to reproduce the actual expansion. The arrangement of having one indicator at each end of the cylinder is always to be preferred.

67 The applications of this method must be made with judgment and care. If large leakage exists only an approximate solution can be obtained, as certain assumptions, treated in the section on leakage, have to be made. The various steps involved in the use of the method must be thoroughly comprehended to give satisfaction.

68 *Application of the Method.* The relations of X_c and n, as determined for various pressures at constant speed from the engine tested in the laboratory of the University of Illinois were plotted in the form of the chart shown in Fig. 6.

69 The next step was to examine, with certain restrictions, the tests of other engines, and to compare the relations of X_c and n with those given in Fig. 6. The restricting conditions imposed were: (*a*) that the tests should come from reliable sources; (*b*) that the data supplied should be complete enough for computing the quantities needed for comparison; (*c*) that the cylinders should be non-jacketed; (*d*) that the diagrams furnished should be representative of average conditions; (*e*) that the back pressure in the cylinder examined should be practically atmospheric; (*f*) that no large leaks should exist.

70 The values of X_c, n and p were first found from the set of diagrams to be examined. Next, the values of n and p were located in Fig. 6 and the corresponding value of X_c found, as obtained in the tests. The value of X_c obtained from the chart and that obtained from the test examined were compared, and the steam consumption, as computed by the value of X_c taken from the chart, was obtained.

71 The results of tests which fulfilled the conditions imposed are given in Table 4. Four distinct classes of engines were examined. These include simple Corliss, two-valve and four-valve types, the high pressure cylinders of compound engines, the intermediate pressure cylinders of triple expansion engines, high-speed and simple

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[1] Trans. Am. Soc. M. E., vol. 17, p. 398.

locomotive engines. The sizes range from $10\frac{1}{2}$ in. by 12 in. to 34.2 in. by 60 in., and the speeds from 263 to 47.98 r.p.m.

72 The final results, given in columns 24, 29, 31 and 36 of Table 4 were averaged (analysis 201 excepted) and the averages are given as follows:

APPROXIMATION FROM CHART—FIG. 6

Average Difference from Test Results	Value of X_c, Per Cent	Actual Steam Consumption, Per Cent
Irrespective of sign...........	3.06	3.72
Higher (+) or lower (−) than test results...............	−1.93	+2.50

APPROXIMATION FROM EQUATION $X_c = 1.245\,n - 0.576$

Irrespective of sign...........	3.32	3.98
Higher (+) or lower (−) than test results...............	−1.32	+1.91

Analysis 201 shows an application, the conditions of speed and cut-off pressure of which are far outside of the limits examined. The values given were obtained by extrapolating as straight lines the lower portions of the curves of constant value of X_c in the chart of Fig. 6. Although the speed is only 27.66 r.p.m. and the cut-off pressure only 38.5 lb. absolute, the value of X_c by chart was determined as 0.470, while the value by test is 0.508, a difference of 7.5 per cent, based on the test value of X_c. This application is given to show that an extrapolation of the method to unusual conditions of speed and cut-off pressure does not lead to absurd results, although it is not nearly as accurate as the applications to speeds higher than 50 r.p.m.

73 The results of the applications made up to the present, with the restricting conditions imposed, tend to show that the steam consumption of engines may be approximated from the indicator diagram to within an average difference of less than 4 per cent from the test results. Individual examples, however, may show as much as 8 per cent difference in rare cases.

CONCLUSIONS REGARDING STEAM CONSUMPTION FROM DIAGRAMS

74 The following conclusions have been drawn from the results of the investigation, as applicable to non-jacketed steam cylinders in good physical condition exhausting at or near atmospheric pressure, and with the limitations imposed as already given.

a At a given initial pressure and speed of engine, there is a definite relation existing between X_e and n, in any one cylinder, which is practically independent of the cut-off position.

b This relation is practically independent of cylinder size and of engine speed; it is therefore applicable to other cylinders of the same type.

c By means of the experimentally determined relations of X_e and n, the value of X_e may be approximated from the average value of n obtained from the expansion curves of one set of indicator diagrams, taken simultaneously; therefore the actual weight of steam present in one revolution may be approximated.

d The actual steam consumption may be obtained by this method from the indicator diagram to well within an average of 4 per cent of the amount consumed as measured by test.

e This method has the following advantages not possessed by tests: it is more accurate than the average test, and is the only accurate method available for testing certain classes of engines; it virtually measures an instantaneous rate instead of an average quantity over a long time, and thus enables a large number of points to be obtained for a water-rate curve; it permits of making tests at frequent intervals instead of once in the engine's life; the expense is not to be compared with that of an equally accurate test; it involves no change in the routine of the plant tested.

THE LOGARITHMIC DIAGRAM APPLIED TO ALL ELASTIC MEDIA

75 *The Form of Expansion and Compression Curves from Practice.* About 300 indicator diagrams from 50 engines using steam, gas, air, and ammonia have been examined[1] to investigate the form and character of the expansion and compression curves. It may be stated as a result that the polytropic law $PV^n = C$ holds for all elastic media with certain exceptions which have been studied and the causes treated.

76 An example of two logarithmic diagrams showing how perfectly the law holds is given in Fig. 9. These diagrams were constructed from two indicator diagrams shown in Fig. 15 taken from the Corliss engine tested.

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[1] See Appendix for examples and discussion.

77 *Mathematical Relations of the Law,* $PV^n=C$. The equation of the polytropic curve, $PV^n=C$, when plotted on rectangular cross-section paper, gives a curve depending for its form and position on the values of P, V, n, and C. When this curve is plotted on logarithmic paper it becomes a straight line depending for its slope on the value of n and for its position upon the value of C. The relations for such curves are:

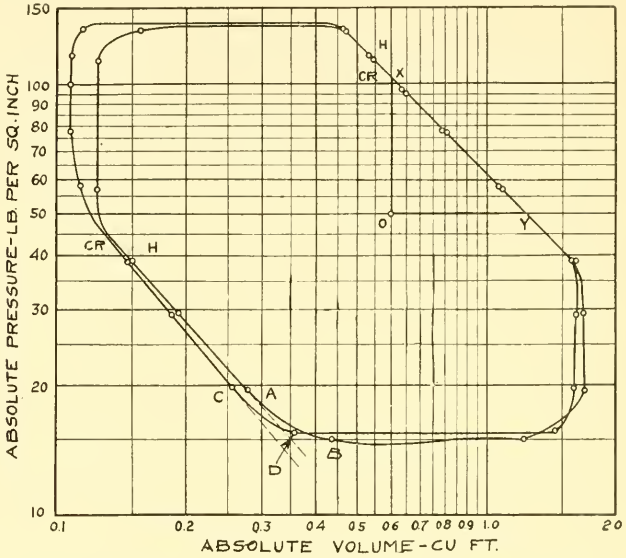

FIG. 9 LOGARITHMIC DIAGRAMS PLOTTED FROM FIG. 15

Given

$$PV^n=C$$

Taking the logarithm of both terms

$$\log P+n\log V=\log C$$

Transposing

$$\log P=-n\log V+\log C$$

This equation is of the form of the straight line

$$y=mx+b$$

where

$$y=\log P$$

$$m=-n$$

$$x=\log V$$

$$b=\log C$$

Thus $m=-n$, the slope, or measure of inclination of the line to the axis log V. In Fig. 9, for example, at a point X on the line

$$\log P=-n \log V+\log C$$

draw OX parallel to the axis log P, and draw OY parallel to the axis log V. The slope of the line will be the value of the ratio $\frac{OX}{-OY}=-n$. OY is negative, being measured to the left, giving n its negative sign.

78 *Use of the Logarithmic Diagram.* The logarithmic diagram forms the basis of the methods of analyzing the cylinder performance of reciprocating engines which are developed in detail in the following pages.

79 These methods apply only, however, to the logarithmic diagrams derived from the cylinders of reciprocating engines using an elastic fluid for the working medium and having, as a part of the cycle of operation, an expansion, a compression, or both.

80 The figures of one set of indicator diagrams and the corresponding set of logarithmic diagrams are numbered the same, but the letters a and b are used in addition to the figure number to denote the indicator and logarithmic diagrams, respectively.

RATIONAL METHOD OF APPROXIMATING CLEARANCE

81 In the cases of the great majority of the PV-diagrams which were examined,[1] the expansion and compression curves became straight lines in the logarithmic diagram, showing that the law $PV^n=C$ was applicable, or in other words, that n was a constant for one curve. The clearances furnished with the diagrams examined had been carefully found by the displacement method.

82 It was desired to see what forms the lines assumed when the clearance was taken larger or smaller than the measured quantity. The diagram shown in Fig. 10-a, taken from a 42 in. by 60 in. gas engine, was used for this purpose. The true clearance, measured as 18.0 per cent, was used in the full logarithmic diagram of Fig. 10-b. Trials were made with clearances assumed as 14.0, 16.0, 20.0, and 22.0 per cent of the piston displacement. With the true clearance of 18.0 per cent, the curves became almost perfectly straight lines, while with the values of clearance less than 18.0 per cent, it is seen that the lines become bent to the left, and with values of over 18.0 per cent the lines become bent to the right. Hence the straight

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[1] See Appendix for examples and discussion.

line for the value of 18.0 per cent is the transition between the family of curves bending to the left, representing a clearance smaller than the real value, and the family of curves bending to the right, representing a clearance larger than the real value.

83 The practical significance of this fact is that there is now available a rational method of approximating the clearance of any cylinder using an elastic medium, which has, as a part of the cycle of operation, an expansion or a compression. This method is based on the fact, already mentioned, that in practice all elastic media, except under certain exceptional conditions, obey substantially the law $PV^n = C$, when subject to change of state, and therefore become straight lines in the logarithmic diagram.

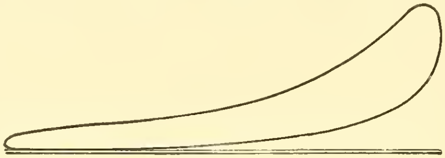

Fig. 10-*a*

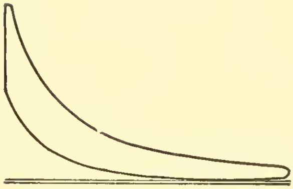

Fig. 11-*a*

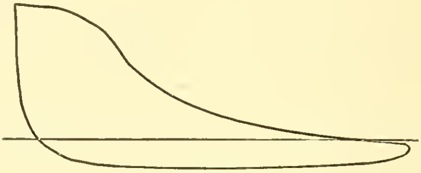

Fig. 13-*a*

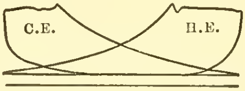

Fig. 14-*a*

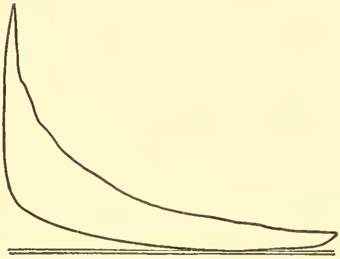

Fig. 12-*a*

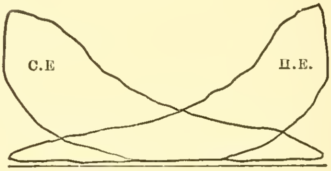

Fig. 16-*a*

Diagrams from Gas Engines, Corliss Engine, Compressor and High-Speed Steam Engine

84 *Graphical Method of Approximating Clearance.* The graphical method of approximating clearance requires only the scale of the

indicator spring to be known, and the atmospheric line to be drawn, in order to locate the zero line of pressure. The exact order of procedure necessary to make a trial, and the degree of accuracy obtained in any given case, is shown in detail in Par. 93 for a $25\frac{5}{8}$ in. by $37\frac{5}{8}$ in. gas engine. All that is necessary is to assume different values of clearance, and plot the logarithmic diagram for each assumed value. The straight line position of the curves is found by trial and error, to lie between the two diverging families of curves representing too small and too large clearance.

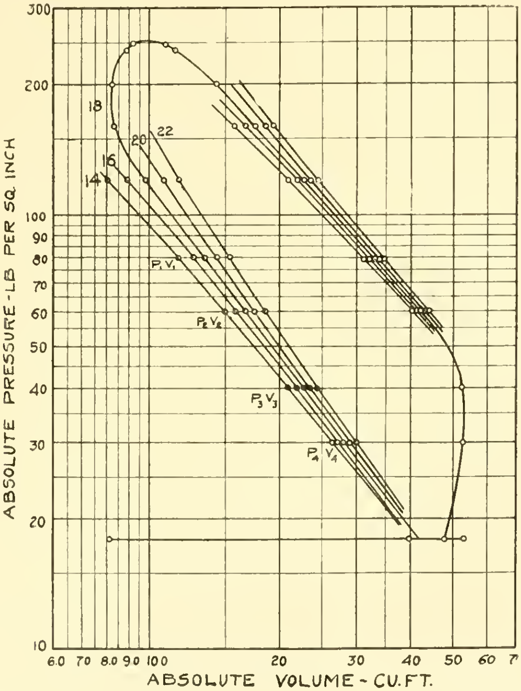

FIG. 10-b TOD 42 IN. BY 60 IN. GAS ENGINE, BLAST FURNACE GAS

85 It follows also from the curves shown by Fig. 10-b that the clearance being known, the scale of the spring used may be obtained in the same manner if the atmospheric line is given.

86 *Mathematical Method of Approximating Clearance.* The results obtained from the graphical method of trial and error may also be accomplished by the use of the purely mathematical process upon which the method depends.

87 The law $PV^n = C$ holds, thus n is a constant for any part of the curve. When the wrong clearance is used, the law $PV^n = C$ does not hold, and n varies from point to point. In the graphical method, trials of various values of clearance are made, until the curve becomes approximately a straight line; this resultant straight line is, therefore, the law $PV^n = C$, in which n is a constant for all parts of the curve. The one condition necessary to be fulfilled, therefore, is that n be constant for all parts of the curve, but not of any particular value.

88 To illustrate the use of the mathematical method in Fig. 10-b, let us assume several points, as P_1V_1, P_2V_2, P_3V_3, and P_4V_4 at various intervals on one of the curves, as on the compression curve at the clearance value 14.0 per cent. It is desirable for convenience to locate the points at about equal intervals, as shown. The law $PV^n = C$ is assumed to hold. Then, for two points, P_1V_1 and P_2V_2, called group *a*, we have

$$P_1V_1^{\,n} = C$$

$$P_2V_2^{\,n} = C$$

Equating these, we obtain

$$P_2V_2^{\,n} = P_1V_1^{\,n}$$

Transposing and dividing

$$\left(\frac{V_2}{V_1}\right)^n = \frac{P_1}{P_2}$$

Taking the logarithm of both sides

$$n\,(\log V_2 - \log V_1) = \log P_1 - \log P_2$$

Whence

$$n_a = \frac{\log P_1 - \log P_2}{\log V_2 - \log V_1} \dots\dots\dots\dots\dots\dots [1]$$

In the same manner for the points P_3V_3 and P_4V_4, called group *b*, is obtained

$$n_b = \frac{\log P_3 - \log P_4}{\log V_4 - \log V_3} \dots\dots\dots\dots\dots\dots [2]$$

For the correct value of clearance, the following condition must be fulfilled by trial and error

$$n_a = n_b \dots\dots\dots\dots\dots\dots\dots\dots [3]$$

89 The values of the logarithms of the coördinates of all the points are then found, and the values of n_a and n_b computed. If the points are located in the order shown, then with too small a clearance, n_a is lower in value than n_b. A larger value of clearance is then assumed, the operation being merely to add a constant number

to the values of V_1, V_2, V_3, and V_4. The process is repeated until the value of n_a becomes practically equal to n_b. When the clearance is assumed too large, n_a becomes higher in value than n_b, indicating that the true value has been passed.

90 The trial by the mathematical method is neither as accurate nor as short as the graphical method. It is not as accurate because the points assumed may not be representative. When this is the case, the graphical method allows judgment to be exercised in selecting the straight-line position, thereby eliminating irregularity of points.

91 The question arises as to whether the form of the lines due to wrong clearance can be distinguished from the form due to leakage or to "hooks," on the logarithmic diagram. This case is treated in Par. 126.

92 The curve of the PV-diagram nearest the clearance space, or the compression curve in Fig. 10-b, is generally the better guide in the graphical trials. This is well shown in Fig. 10-b. A given difference in the values of clearance used for trial causes more horizontal variation in the position of the compression curve than in the expansion curve. This fact allows closer locations of the straight-line transition region to be made from the compression curve than from the expansion curve.

93 *Examples.* It was desired to determine the clearance of the diagram shown in Fig. 11-a. From general knowledge of this class of engines a trial by the graphical method was made in Fig. 11-b with the clearance assumed as 12.4 per cent, a value purposely assumed as being too small. This value is seen, by the bending of both curves to the left, to be much too small. Trials were, therefore, made with the clearance assumed as 13.8, 15.1, and 16.0 per cent of the piston displacement. The values of 15.1 per cent gave practically straight lines for both the expansion and compression curves, while the value of 16.0 per cent shows that the lines have begun to bend to the right, indicating too large a clearance. By inspection, it will be seen that the region of fairly straight lines may be located as lying between the values of about 14.5 per cent to 15.5 per cent. The clearance is, therefore, selected as 15.0 per cent, a value which may be high or low by not more than 4 per cent in this case. This clearance value, 15.0 per cent, is a common value for engines of this class.

94 The graphical method is more accurate for large clearances, measured in per cent of the piston displacement, than for small ones.

The closeness of location of the straight-line region, lying between the two families of diverging curves, will be found to be within 5 per cent to 10 per cent of the clearance volume, for values of clearance between 20 per cent and 2 per cent, respectively, of the piston displacement.

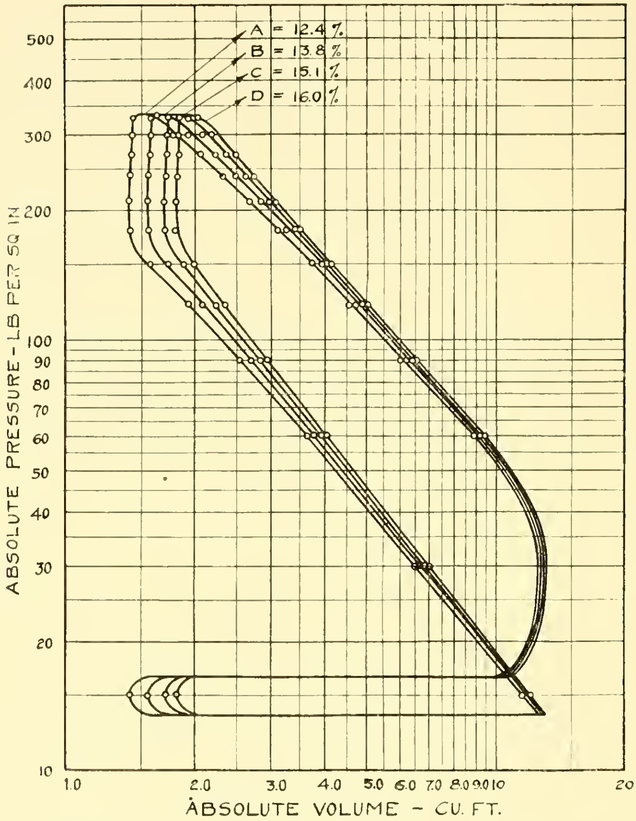

Fig. 11-b Koerting 4-Cycle $25\frac{5}{8}$ in. by $37\frac{5}{8}$ in. Producer Gas Engine

RATIONAL METHOD OF LOCATING THE STROKE POSITION OF CYCLIC EVENTS

95 It is often desirable to know at what part of the stroke the cyclic events occur. This knowledge can be best obtained from the *PV*-diagram. For ordinary purposes, these events can be closely located by inspection on the *PV*-diagrams themselves, in most cases; thus, on a diagram from a Corliss engine, cut-offs may generally be

located to within $\frac{1}{16}$ in., measured along the length of the diagram.

96 The actual beginning of true compression, however, can *never* be accurately located on the *PV*-diagram. True compression, unaffected by leakage, begins after the exhaust valve, in closing, has acquired enough seal to prevent leakage. The point of the beginning of true compression is generally at least 5 lb. above the back pressure. The point at which leakage ceases cannot be located on the *PV*-diagram because the curve of true compression, and the curve during the time the valve has insufficient seal, are of the same direction of curvature, and are not reverse curves as in the general case of admission and expansion.

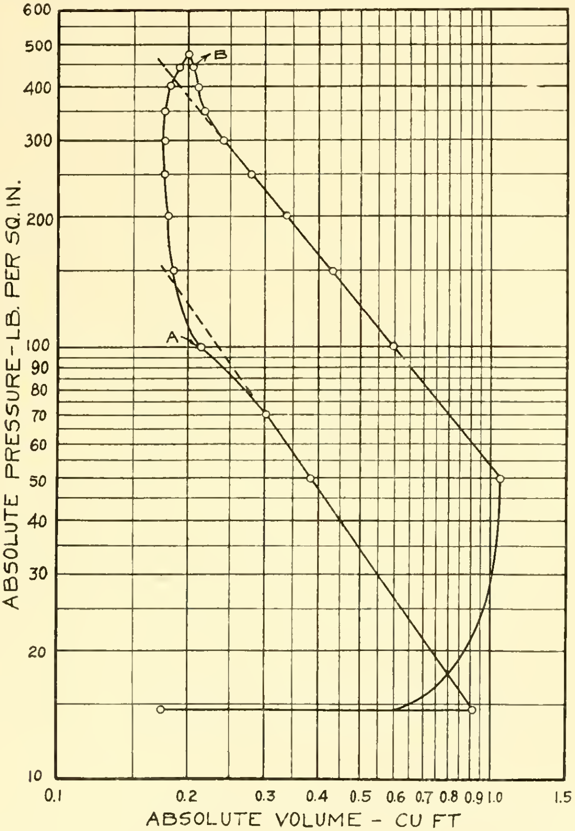

FIG. 12-b GAS ENGINE 10 IN. BY 19 IN. FOR ILLUMINATING GAS

97 The fact that expansion and compression of a constant weight of medium takes place[1] according to the law, $PV^n = C$, thus becoming straight lines in the logarithmic diagram, enables us to locate cyclic events very closely, even in cases where they cannot be detected at all in the PV-diagram.

98 An example is shown in Fig. 21-a, containing locomotive PV-diagrams taken at short cut-off and high speed. The events of cut-off, release, compression, and lead are very difficult to locate on such diagrams. These events are located on the logarithmic diagram in Fig. 21-b by noting when the expansion and compression curves become straight, indicating a constant weight of steam mixture.

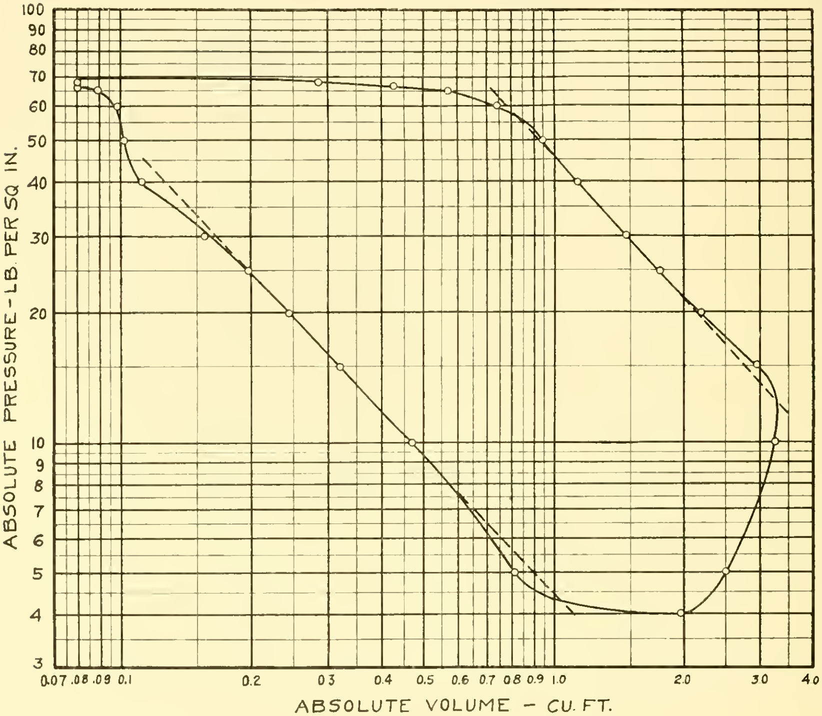

Fig. 13-b Corliss Engine 14 in. by 35 in.

99 A sufficient number of points are plotted to show clearly the direction of the diagram near the events desired. Thus these events,

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[1] See Appendix for examples and discussion.

even though obscure in the PV-diagram, may be located to well within about $\frac{1}{16}$ in. in the logarithmic diagram, this length being equivalent to about $\frac{1}{32}$ in. when retransferred to the PV-diagram itself.

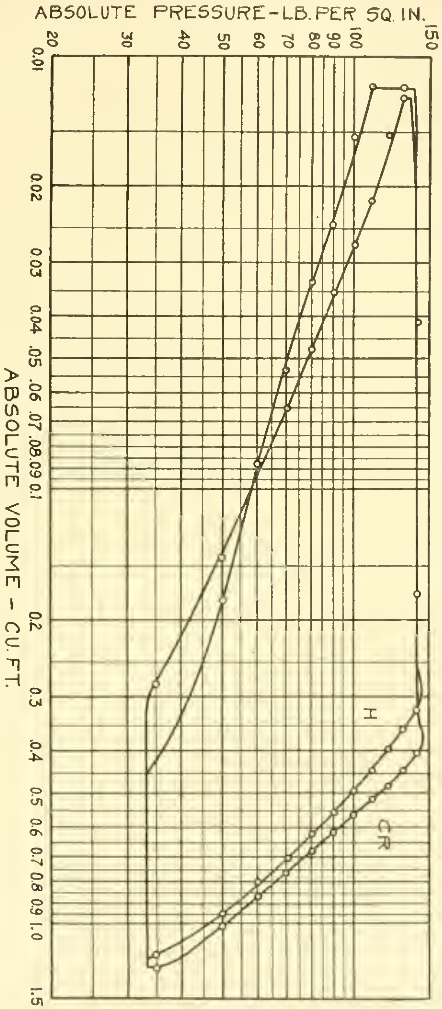


FIG. 14-b AMMONIA COMPRESSOR $11\frac{1}{4}$ IN. BY 22 IN.

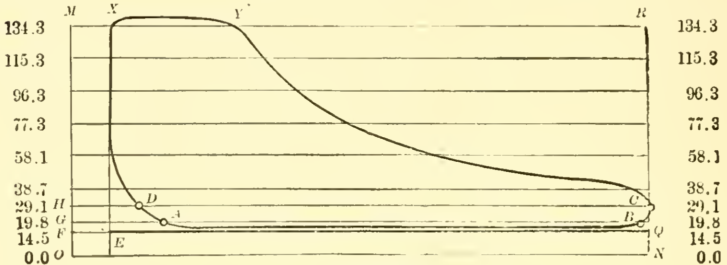
100 The use of this method has one great advantage in that it largely eliminates the variable element of personal judgment. It is a common occurrence to see PV-diagrams where two persons have

located an event such as cut-off, $\frac{1}{8}$ in. apart, each location being the best judgment of the person doing the work. The logarithmic diagram will at all times give closer locations of events for these reasons than will the PV-diagrams.

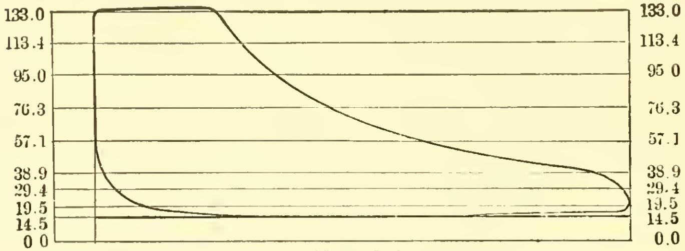
101 The method also allows the point of true compression to be located, the location of which is practically impossible in the PV-diagram.

RATIONAL METHOD OF DETECTING LEAKAGE

102 The law $PV^n = C$ is applicable only to cases where the weight of the working medium remains practically constant during any expansion or compression. When this weight changes materially, either by leakage into, or out from, the cylinder containing the medium, the resulting expansion or compression no longer obeys the law, and it becomes a curve on logarithmic cross-section paper. This fact is very clearly shown in the curves of the logarithmic diagram derived from cylinders in which large leaks were known to exist.



Crank End



Head End

Fig. 15 Diagrams taken from Test 30, Table 1, 12 in. by 24 in. Corliss Engine

This and the Subsequent Diagrams are referred to in the Appendix and are given to illustrate Typical Logarithmic Diagrams

103 *Examples of Known Leakage.* The first case, shown in Fig.

12-b, occurred in a 10 in. by 19 in. gas engine, intended for producer gas, but using illuminating gas at high compression. The piston, a single-acting trunk type, allowed a large leak, clearly detected by the noise of escaping gas, at the beginning of the combustion stroke. Both the compression and expansion curves show the effect of this leak in a clear manner when transferred to the logarithmic form. After that portion of the stroke was reached where no sound of leakage was heard, the two curves became straight lines. This indicated very clearly that the effect of leakage, if appreciable, may be detected in the form of the curves of the logarithmic diagram.

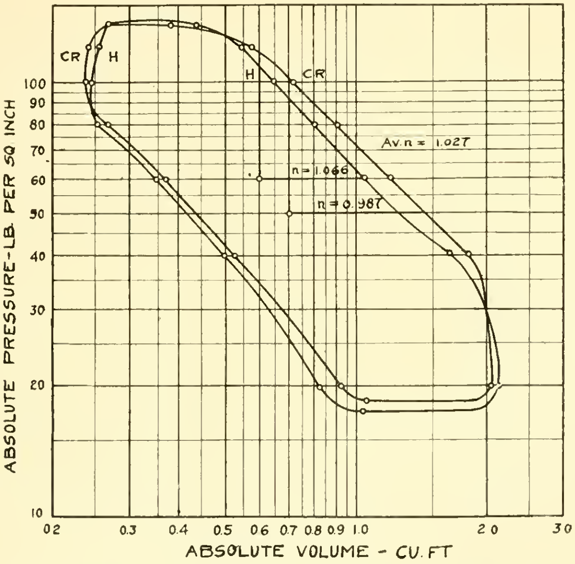


Fig. 16-b Ide 16 in. by 16 in. High-Speed Steam Engine

104 The second case, shown in Fig. 13-b, is from a 14 in. by 35 in. Corliss engine. The knowledge of the leaky condition of the piston and valves came from the engineer in charge.

105 The expansion and compression lines indicate by their form at the upper ends, a large leak from the cylinder, or through the exhaust valve. The lines also show, by the rising of the curves at the lower ends, a considerable addition to the steam in the cylinder during expansion and compression. This steam could come only from a large leak in the steam valve. The seven other diagrams taken

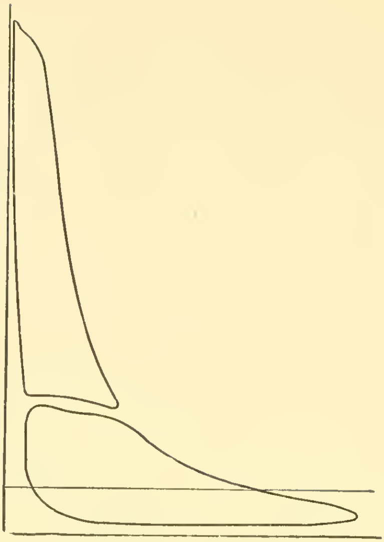


Fig. 17-a Diagram from Rice and Sargent 16 in. by 28 in. by 42 in. Superheated Steam Engine

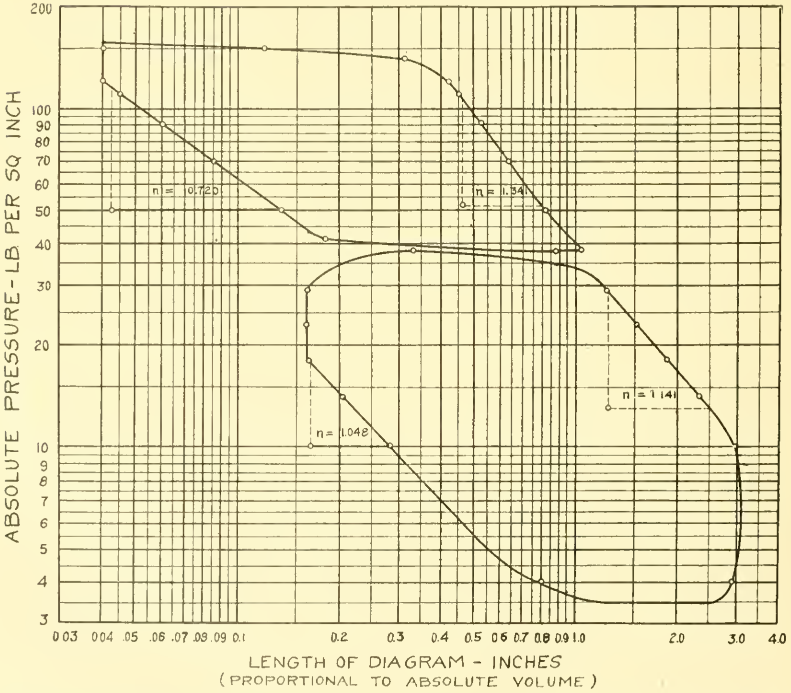


Fig. 17-b Rice and Sargent 16 in. by 28 in. by 42 in. Steam Engine Using Highly Superheated Steam

from this same engine all showed the effect of leakage in a similar manner.

106 The third case of known leakage, shown in Fig. 14-b, is from an $11\frac{1}{4}$ in. by 22 in. double-acting ammonia compressor. This cylinder was known to be in a very bad condition as regards wear and leakage of piston and valves. The re-expansion curves, by the enormous amount of re-expansion shown, indicate large leakage into the cylinder during this operation. The lower part of the compression curves, by rising, indicates leakage into the cylinder, either past the piston or through the discharge valves. The upper part of these curves indicates leakage from the cylinder, either past the piston or through the suction valves.

107 These three examples show abnormal conditions which are comparatively rare. Very smooth curves may be obtained in the PV-diagram even if there is large leakage taking place. This is seen by referring to Fig. 13-a, both the expansion and compression curves being fairly regular. The logarithmic diagram, however, shows clearly, in connection with the discussion and the examples shown, that large leakage of two kinds was taking place during expansion and compression. Leakage which occurs during admission or during exhaust has no effect upon the lines of the diagram as the weight of the medium is continually changing.

108 *Method of Detecting Leakage.* When leakage occurs in a cylinder, it is seldom found that only one source of leakage exists. Leakage is usually the result of wear, which affects most of the possible sources of leakage in about an equal proportion. As a result, several leaks are generally affecting the curves. This is the case in Fig. 13-b and 14-b. In Fig. 13-b leakage was taking place both into and out from the cylinders.

109 In discussing leakage, it must be kept in mind that difference in pressure between two regions is the cause of this phenomenon. In the steam engine, there are three pressures which must be considered, i. e., the pressure in the steam chest, in the cylinder at the point discussed, and in the exhaust passage. Leakage, being due to difference of pressure, becomes material only when this difference becomes considerable. Thus leakage into, or out from a steam cylinder has been found to occur in most cases only when the pressure difference is over about 20 lb. In Fig. 13-b, the leakage into the cylinder, shown by the lower parts of the lines, begins to occur at about 25 lb. absolute, or 35 lb. lower than the pressure at admission. The leakage out from the cylinder, shown by the upper parts of the

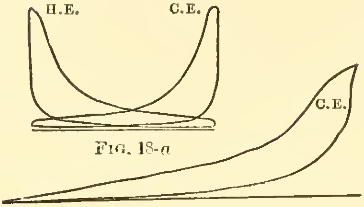


Fig. 18-*a*

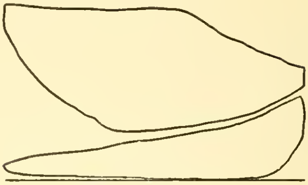


Fig. 19-*a*

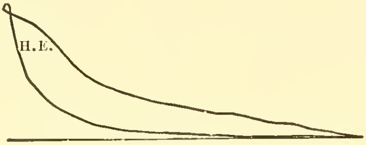


Fig. 21-*a*

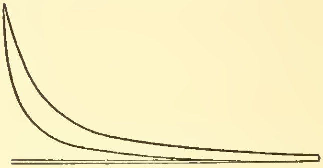


Fig. 22-*a*

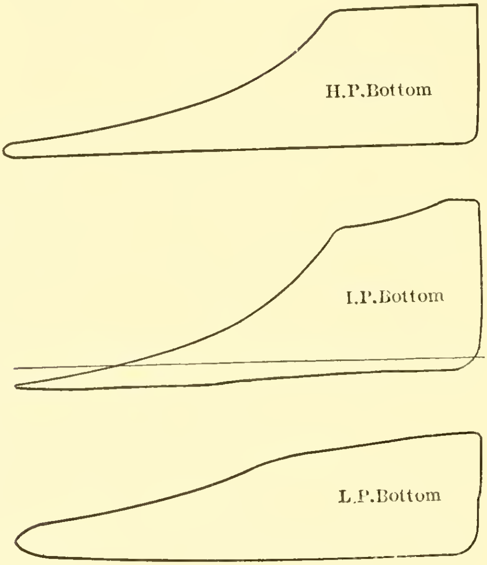


Fig. 20-*a*

Diagrams from Stumpf Engine, Single-Acting Westinghouse, Locomotive, Diesel Engine and Pumping Engine

lines, ceases to occur at a pressure of about 40 lb. absolute for the expansion curve, and begins to occur at about 25 lb. absolute for the compression curve. The difference of pressure between the steam in the cylinder and that in the exhaust passage is about 35 lb. in the first case, and about 20 lb. in the second case.

110 This fact, founded on many diagrams analyzed enables us to

divide the expansion and compression lines roughly into three equal parts on the logarithmic diagram (when these lines extend from the initial pressure nearly to the back pressure): (*a*) the upper third, influenced by leaks *out from* the cylinder; (*b*) the middle third, practically *uninfluenced* by leakage; (*c*) the lower third, influenced by leakage *into* the cylinder. Thus fairly reliable values of *n*, free from the effect of leakage, may be obtained from the middle third of the lines.

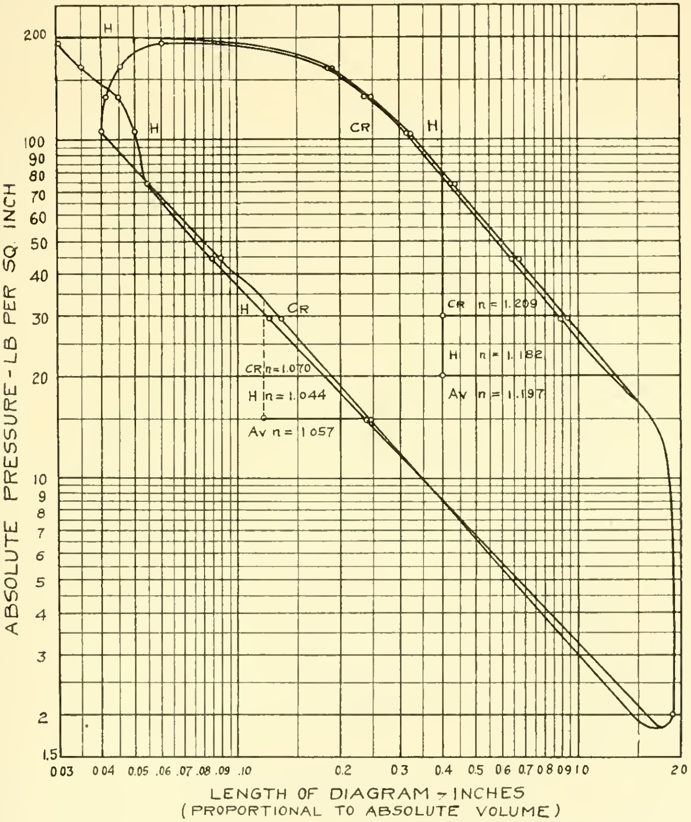


FIG. 18-b STUMPF $23\frac{1}{2}$ IN. BY $31\frac{1}{2}$ IN. UNI-DIRECTIONAL FLOW STEAM ENGINE USING SUPERHEATED STEAM

111 Returning to Fig. 13-*b*, both the lines indicate leaks out from the cylinder. This can occur either past the piston or through the exhaust valves. The piston generally becomes leaky sooner than

Corliss exhaust valves, and, in this particular engine, one of the piston rings was found to be broken upon examination. When diagrams from both ends of the cylinder are available, piston leakage causes nearly an equal effect on the expansion curves of both ends. The leakage into the cylinder can come from only one source which can influence the curves, i. e., the steam chest. The effect of this leak is seen in both lines in the lower thirds.

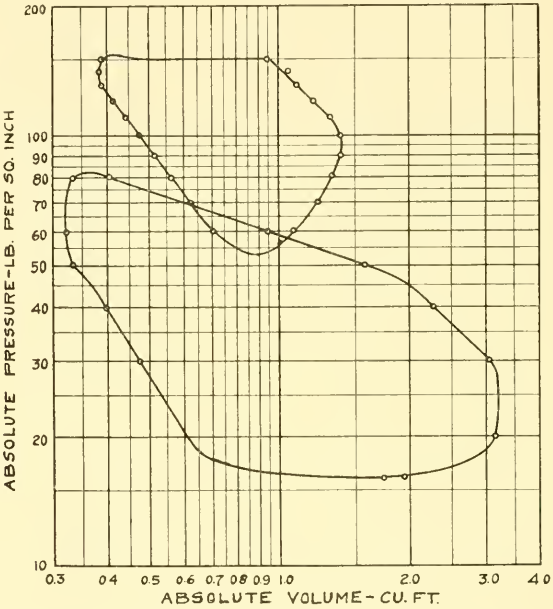


Fig. 19-b Westinghouse Single-Acting 13 in. by 22 in. by 13 in. Steam Engine

112 In Fig. 14-b, both forms of leakage are shown in the ammonia compression curves. The lower thirds show leakage into the cylinder, either through the discharge valves or past the piston. The upper thirds of the lines show large leakage from the cylinder, caused by the condition of either the suction valves or the piston. Ordinarily, it is not possible to distinguish between two leaks occurring in the same third of the curves.

113 *Approximation of the Volume Which Leaked.* Fig. 12-b is an example where only one kind of leakage is present. Here, the piston alone leaked badly at the commencement of the stroke. The effect of this leak is seen in the upper third of both lines.

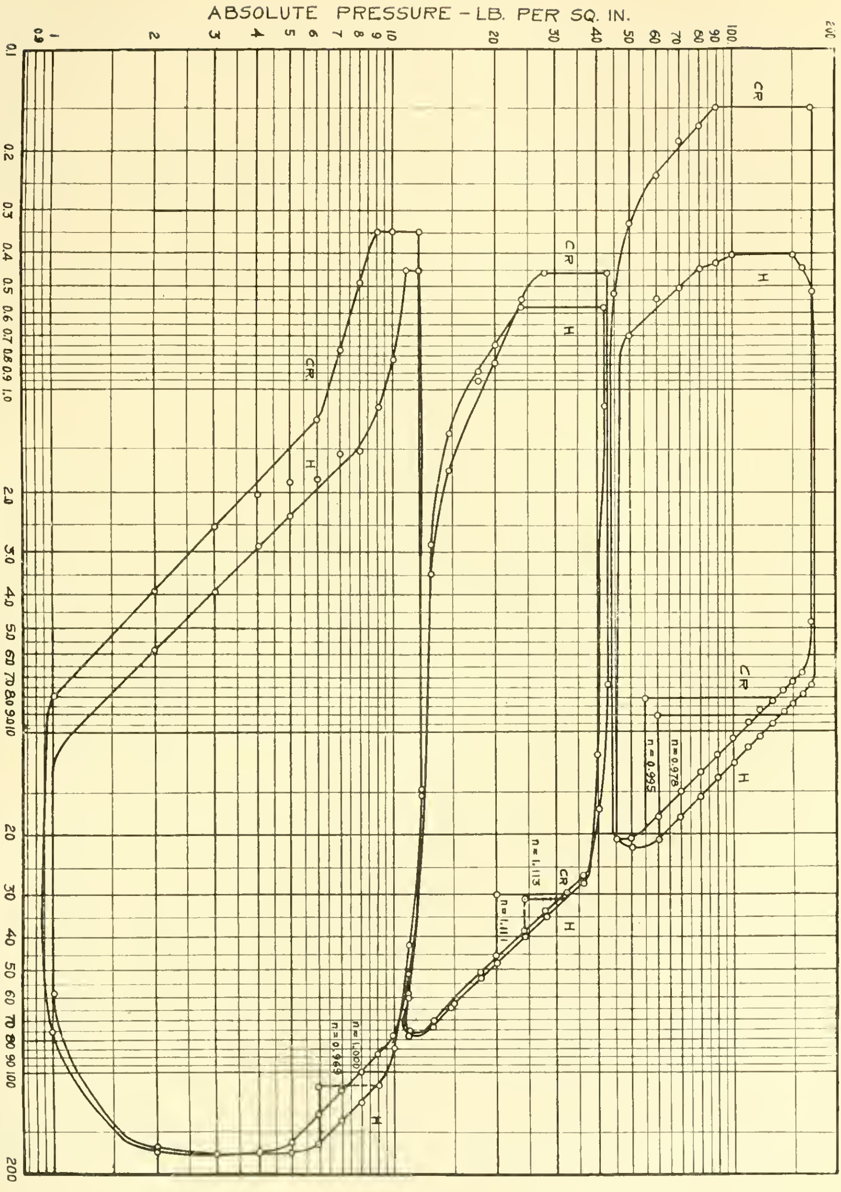


Fig. 20-b Allis-Chalmers Pumping Engine 28 in. by 54 in. by 80 in. by 60 in. Saturated Steam

114 When only one kind of leakage exists it is possible to compute with fair accuracy the volume of leakage taking place during expansion or compression. The lines are extended, as shown in Fig. 12-b, giving the lines of constant weights of the medium. The volume of gas that had leaked during compression, up to 100 lb. absolute pressure, is then seen to be 0.014 cu. ft., or 6.3 per cent of the volume remaining. The volume of gas, measured at the pressure of 450 lb. absolute, that leaked after combustion during expansion, is seen to be 0.032 cu. ft., or 18.7 per cent of the volume remaining after the leakage stopped.

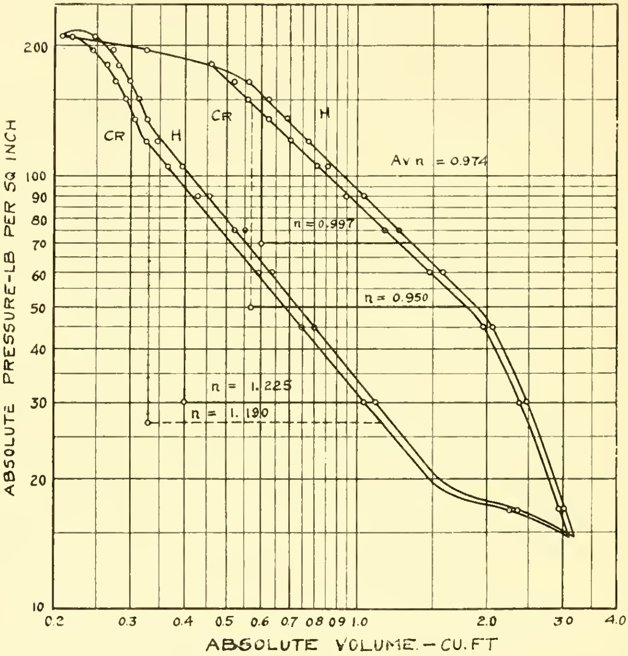


Fig. 21-b Purdue 16 in. by 24 in. Superheated Steam Locomotive

115 The leakage that took place during combustion at the end of the stroke cannot be computed, but it can be estimated by making the assumption that this leakage was proportional to the mean rate of leakage shown by the two curves, and that its duration was the time interval occurring between the point A and the point B.

116 The important result that is attained by this method is not,

however, the approximation of leakage, but the knowledge that it is taking place, so that it can be located and stopped.

117 *The Use of the Method in Testing for Maximum Economy.* Many engines are sold and their prices fixed on the basis of their test performances. The importance to the manufacturer of being able to eliminate leaks during this test does not have to be emphasized. Does the engineer in charge of the test know whether the engine is tight under regular operating conditions?

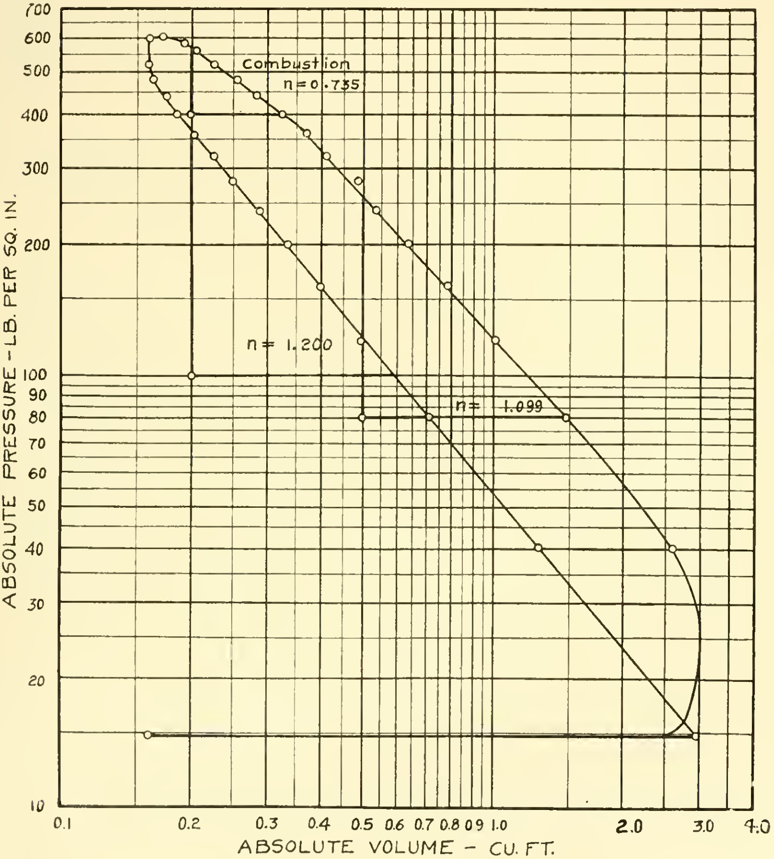


Fig. 22-b Diesel 16 in. by 24 in. Oil Engine, Crude Oil

118 All of our present knowledge of leakage is an inference drawn from the leakage "standing." Nobody knows whether an engine

that is tight "standing" leaks when in operation, or vice versa.

119 This method should be applied to all engines about to undergo any test where maximum economy is the object desired.

120 The results of an analysis made in connection with this investigation by means of logarithmic diagrams of a large number of PV-diagrams, indicate that the majority of engines, in good condition, are practically tight as regards leakage into or out from the cylinder.

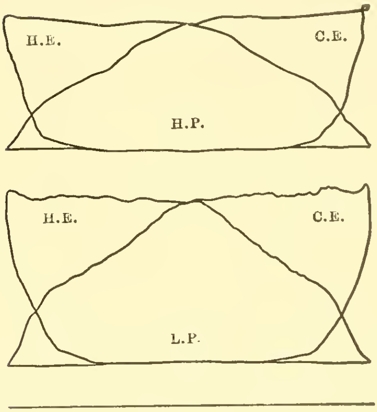


Fig. 23-*a*

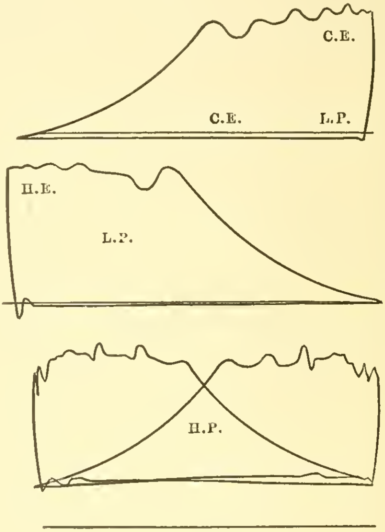


Fig. 24-*a*

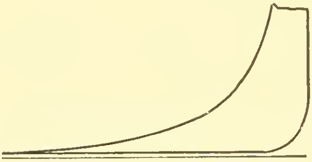


Fig. 25-*a*

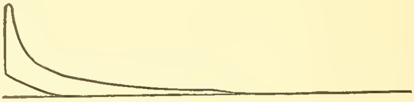


Fig. 26-*a*

Diagrams from Compound, Two-Stage Air Compressor, Single-Acting Ammonia Compressor and Corliss Engine when Starting

121 Most leakage is the result of wear and tear due to long and hard use. After the wear and tear has become marked, it is the custom to rebore the cylinder and to resurface the valves and valve-seats. Some railroad companies overhaul the cylinders and valves of locomotive cylinders at regular intervals of, for instance, 150,000 miles of travel. Some cylinders in stationary plants are rebored at equal time intervals of some four or five years each.

122 As a pure question of economy, other things not considered, general repairs of cylinder and valves should take place when the extra annual cost of fuel and water due to leakage equals the annual interest on the money necessary for general repairs.

123 It is apparent that the existing methods of determining when general repairs are necessary are in a very haphazard state as regards economy, and that the personal judgment of the man making the decision may be liable to great variation.

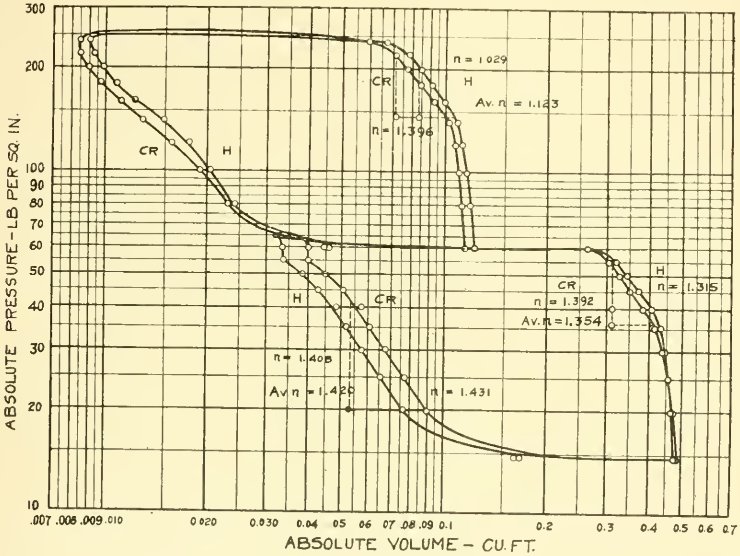


Fig. 23-b Porter Air Locomotive-Compound 5 in. by 10 in. by 10 in.

124 The method of detecting leakage from the logarithmic diagram offers a more rational solution of this important question.

INTERPRETATION OF THE LOGARITHMIC DIAGRAM

125 In the discussion upon the effect of wrong clearance, leakage, and excessive condensation[1] upon the lines of the logarithmic diagram, it was assumed, for the sake of clearness, that only one of these effects existed at one time. The examples were selected so as to illustrate only one of these effects in each case.

126 Cases occur where several of these effects exist at one time in the same diagram. The separation of one effect from another is not an exact process. However, the character of the curves showing

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[1] Discussed in Appendix.

excessive condensation, wrong clearance, and leakage are quite different. For instance, wrong clearance affects the lines throughout their length. Excessive condensation, in the cases of the steam diagrams examined, always affects only the upper parts of the curves. Leakage, as has been mentioned, affects materially only the upper and lower thirds of the lines, where these lines extend

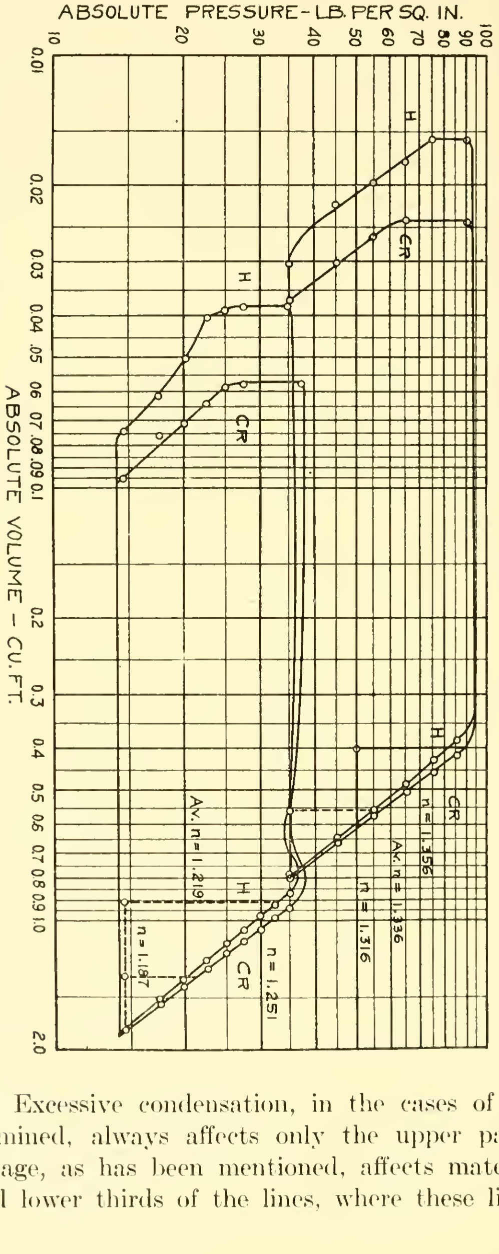

FIG. 24-b INGERSOLL-SEARGENT $12\frac{1}{4}$ IN. BY $18\frac{1}{4}$ IN. BY 12 IN. TWO-STAGE AIR COMPRESSOR

from the initial pressure to nearly the back pressure. When excessive condensation and large leakage exist together, no close approximation of the clearance can be made.

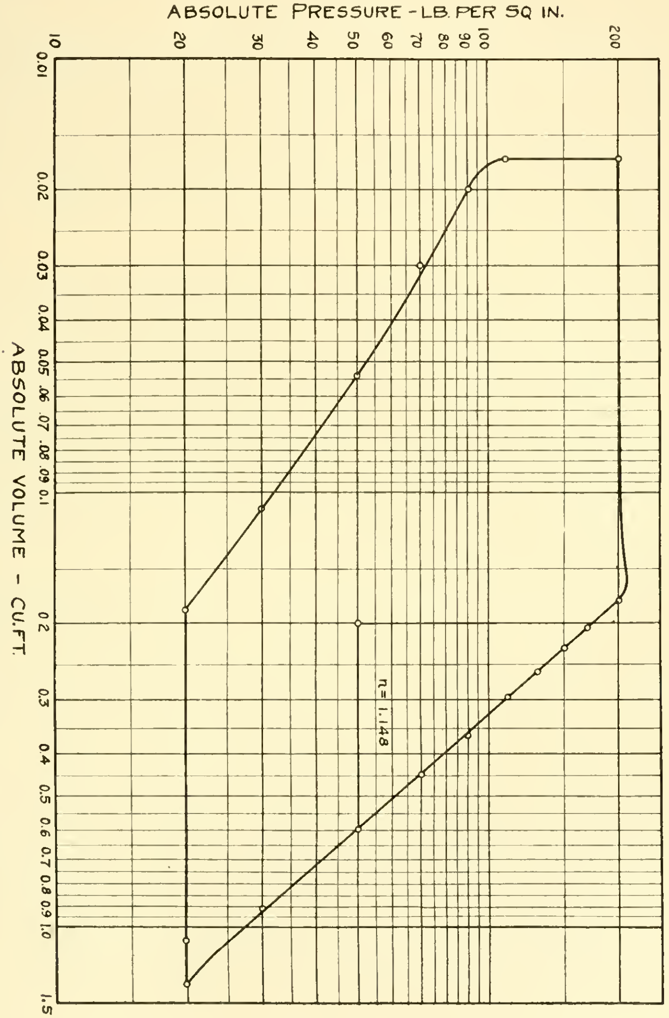

Fig. 25-b York Single-Acting 12½ in. by 18 in. Ammonia Compressor

127 An adequate treatment of the segregation of these various effects, when found together, is beyond the scope of this paper. The treatment is long and complicated. It has been found, however, that experience in the use of logarithmic diagrams enables one to sepa-

rate these effects qualitatively, in some cases, from the form of the expansion and compression curves.

COMMON ERRORS MADE IN ANALYZING STEAM INDICATOR DIAGRAMS

128 *The Use of the Equilateral Hyperbola as a Standard of Comparison.* The values of n for the expansion curves of steam indicator diagrams are not closely constant, but are subject to a very wide range of variation. The extent of this variation may be seen from the examples given in the logs of the tests made, and in the Appendix. The range of variation found in the present investigation is from 0.70 to 1.34.

129 The range of values in the engine tested was from 0.835 to 1.234. The average values were 0.947 for the tests run with saturated steam, 1.056 for the tests run with superheated steam, and 1.004 for all tests. The values of n for most engines of ordinary size using saturated steam at normal cut-off is between 0.95 and 1.05, while for superheated steam the range is usually from 1.00 to 1.30. For saturated steam the value of $n=1.0$ is about an average value. The only meaning that the average value of $n=1$ ever possessed is that the average value of X_c, in the class of engines examined, lies in the range between 0.60 and 0.70.

130 The law of Boyle or Mariotte, or the law of isothermal expansion of a perfect gas, has no bearing of any kind whatsoever on the expansion of steam in a cylinder. The equilateral hyperbola sometimes occurring in steam cylinders is only a special case of expansion according to the polytropic law $PV^n=C$, while Boyle's law is another special case which never occurs in steam engine practice.

131 Because of the agreement in form between Boyle's law and the equilateral hyperbola (the special case of the law, $PV^n=C$, where $n=1.0$), this latter curve has been called the ideal or theoretical curve of expansion to which curves in practice are supposed to approach as a measure of practical perfection in the use of steam. The equilateral hyperbola is in no sense whatsoever an ideal or theoretical curve, and its use for the purposes of comparison is an empirical or arbitrary convention only. It should be called the conventional expansion. It has even been contended that because an expansion curve did not coincide with the equilateral hyperbola, some grave fault exists in the engine. A value of n may be as low as 0.60 with no graver fault than very excessive initial condensation, while a

value of 1.35 may be found from no graver fault than that of using steam superheated about 250 deg. fahr.

132 The only rational use of applying the equilateral hyperbola to steam PV-diagrams is to act as a guide to see whether n is greater or less than 1.0. If the actual curve is not close to this hyperbola, if no faults exist, and if the cylinder is non-jacketed, then this fact means that the value of X_c for the case examined is less than about 0.60 or greater than about 0.70. The assumption that $n=1.0$ as a standard of expansion is equivalent to assuming that the value of X_c is standard at about 0.65. No engineer would seriously propose that the value of X_c of 0.65 should be selected as a standard of economy.

133 The elaborate theory of analysis built on the assumption that $n=1.0$ is the natural result of the use of averages in any art where the actual facts have never been investigated.

134 The use of the equilateral hyperbola to predict the form of PV-diagrams for the purposes of design is satisfactory in the case of ordinary sizes of engines using saturated steam. When steam superheated over 100 deg. fahr. is used, the value of n should be assumed at between 1.10 and 1.25. The high values of n obtained with highly superheated steam in large engines alter materially the division of work and the tangential forces acting from those obtained when n is assumed to be 1.0. This fact should be considered in the design of engines to use superheated steam.

135 The use of the equilateral hyperbola to obtain the ratio known as the "diagram factor" has no rational basis, but its use for this purpose gives results which are valuable for the purpose of design.

136 *The Graphical Method of Approximating the Clearance.* If n has the value 1.0 on a PV-diagram, the clearance may be found by locating the zero of volume on the zero line of pressure. This process is performed graphically by reversing the method used in constructing the equilateral hyperbola.

137 In actual expansions, however, n is almost never exactly equal to 1.0, but is greater or less as already explained. The accuracy of the result by this method is dependent on how close the value of n approximated 1.0. The clearance obtained by this method may be as much as 100 per cent larger or smaller than the actual clearance volume in ordinary cases, while errors of 25 per cent and 50 per cent are very common. Where errors of this size are possible, the method is of no use for important work.

138 A rational method of approximating the clearance cannot be based upon the assumption that $n = 1.0$, but only upon the fact that it be of a constant value, the value itself being immaterial.

139 *Combined Steam Indicator Diagrams.* Very little of value is obtained from the combined PV-diagrams of steam engines, except the measure of the diagram factor for the purpose of design.

140 One of the uses that has been made of the combined diagram is to see whether continuity of expansion exists. It has been assumed by various writers that continuity of expansion should exist. A study of the relations of X_c and n shows that continuity of expansion does not and should not exist except under very special conditions.

141 *Division of Feed for Applying Hirn's Analysis.* One of the requirements of Hirn's analysis is that we know exactly how much steam was admitted to each end of a cylinder. These amounts are not usually equal in practice, so an assumption must be made to cover the needs of the case.

142 The usual assumption is to divide the feed between each end of a cylinder in the ratio of the values of the mean effective pressure shown by the PV-diagrams from the two ends. This assumption is probably not far from the actual division in most cases, and is the best that can be done under the circumstances.

143 In the light of the facts presented in this investigation, this feed may now be divided on a more rational basis. It has been found that the presence of the piston rod in only one end of the cylinder has no appreciable effect upon the value of n. This fact enables us to divide the feed according to the volumes filled and the values of X_c as determined by the resulting values of n. This method is believed to be the closest solution obtainable in the case where the supply for each end of the cylinder cannot be separately measured.

144 *Computing the Weight of Steam Retained in Compression.* A carefully made investigation indicates,[1] when saturated steam is used, that the steam in the cylinder is dry or even very slightly superheated at the closure of the exhaust valve. As shown by the logarithmic diagrams, leakage of the steam in compression continues until the exhaust valve, in closing, has acquired considerable seal.

145 The point which is selected to compute the volume of steam retained in compression generally lies between the points A to B and C to D of Fig. 9. As the weight of steam retained is yet decreasing,

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[1] George Duchesne, Revue de mécanique, July 1899; quoted in Power, Jan. 10, 1911, p. 71.

the point selected nearly always accounts for more steam than was actually retained. In other words, we do not find the value of X_0 to be as high as it actually is.

146 The following method shown in Fig. 9 has been adopted in the present investigation. The straight line of the compression curve on the logarithmic diagram, or the line of constant weight of steam mixture, is prolonged dotted as shown to the back pressure. The intersection of this prolonged line with the back pressure line extended is taken as the volume of dry steam retained in compression. This method almost always gives less steam retained in compression than the ordinary method, and is believed to be rational in the present state of knowledge of this subject.

CONCLUSIONS

147 The following conclusions have been drawn from the results of the investigation relating to all elastic media, as applicable to the cylinders of reciprocating engines using elastic media and having, as a part of the working cycle, an expansion, a compression, or both:

a The indicator diagram, taken by means of a correct reducing motion and with a reliable indicator, contains the evidence necessary for a very complete and useful analysis of cylinder performance.

b The logarithmic diagram, derived from the indicator diagram, discloses a new and very complete analysis of cylinder performance.

c Free from the influences of leakage, wrong clearance, wrong location of the line of zero pressure, and excessively low speed (principally in steam engines), expansion or compression of an elastic medium takes place substantially according to the law, $PV^n = C$.

d The clearance of cylinders may be found by graphical trial in the logarithmic diagram to within 5 per cent to 10 per cent of the clearance volume, depending as the clearance itself varies from 20 per cent to 2 per cent, respectively, of the piston displacement.

e The cyclic events, even though entirely obscure in the indicator diagram, may be located on the logarithmic diagram (when plotted on logarithmic paper of 5 in. per square) to within $\frac{1}{16}$ in., this quantity being the equivalent of about $\frac{1}{32}$ in. when retransferred to the indicator diagram.

f Leakage (if appreciable) may be reliably detected from the logarithmic diagram, and may, in some cases, be approximated in volume.

g The weight of steam retained in compression should be obtained from the logarithmic diagram by prolonging the line of constant weight of steam mixture to the back pressure line extended; the intersection of these two extended lines is the volume of steam which is retained.

148 Acknowledgment is made to Prof. G. A. Goodenough, through whose kind offices permission was secured to undertake the investigation, and who at all times has given his hearty encouragement to the work; also, to Dean W. F. M. Goss, Prof. O. A. Leutwiler, C. M. Garland, Purdue University, and to the various firms who have furnished indicator diagrams and tests for analysis.

APPENDIX

PART 1 METHOD OF CONSTRUCTING THE LOGARITHMIC DIAGRAM

149 The logarithmic cross-section paper used in this investigation consists of four squares arranged two each way. These squares are 5 in. each way, making the four squares together 10 in. each way. The use of four squares enables values to be plotted ranging from 0.1 to 10.0, 1.0 to 100.0, etc., thus giving a range of ten times the values obtainable if only one square were used.

150 *Construction of the Logarithmic Diagram.* The coördinates of the *PV*-diagram are proportional to pressure and stroke, the latter being proportional to the volume displaced by the piston. The coördinates of several points on the *PV*-diagram are found in terms of absolute pressure, preferably in pounds per square inch, and absolute volume, preferably in cubic feet, these being the units used in steam tables.

151 The method of transferring the *PV*-diagram to the logarithmic form is described in detail for the diagrams of test 30, given in Fig. 15. The method of drawing the pressure ordinates is shown in Fig. 15, Crank End. The diagram is shown in outline by *ABYX*. Perpendiculars *QR* and *EX* are drawn to the atmospheric line *EQ*, and pass through the extreme stroke positions of the diagram. The distance *EQ* is then the length of the diagram. *OM* is laid off perpendicular to the atmospheric line *EQ* (extended) which was drawn by the indicator pencil. *OM* is the line of zero volume, and is drawn at a distance *FE* from the admission end *EX* of the diagram, the distance *FE* being the same length in per cent of the line *EQ*, or length of the diagram, as the proportion that the per cent of clearance, or waste space, of the cylinder bears to the piston displacement. In this case the length of the diagram is 3.99 in., and the clearance is 7.04 per cent. The length *FE* is therefore 0.0704 multiplied by 3.99, or 0.281 in. *ON* is the line of zero pressure and is drawn a distance *FO* below the atmospheric line, to the scale of the spring used in obtaining the *PV*-diagram. This distance is proportional to the barometer reading, corrected for temperature, prevailing at the day and place of the engine test. In this case the corrected barometer reading was 14.2 lb. per sq. in. absolute, so the distance *FO* is $\frac{14.2}{79.0}$ or 0.180 in.

152 From *ON* points are laid off on *QR* and *EX* corresponding to the absolute pressures at the intervals where it is desired to read off the corresponding volumes. Fine lines are drawn connecting similar pressure points, as 19.8–19.8, 29.1–29.1, etc. The volumes *G–A*, *G–B*, *H–D*, *H–C*, etc. are read off in hundredths of an inch to the nearest half hundredth. The tabular form used in this investigation is given in Table 6 for the diagrams of Fig. 15 taken in test 30. Thus the length *G–A* is read off as 0.66 in., and is given under the column for 19.8 lb. pressure, headed Compression, for the crank and diagram. The volumes in inches are then multiplied by the constant ratio which 1 in. of length of the diagram bears to the displacement of the piston. From Table 6 it is seen that the piston displacement of the crank end is 1.523 cu. ft., and the length of diagram 3.99 in., hence, the ratio is $\frac{1.523}{3.99}$ or 0.382 cu. ft. of piston displacement per inch

of diagram length. The length *G–A* in cu. ft. of displacement now becomes 0.66 multiplied by 0.382, or 0.252 cu. ft., the volume of steam present at this point. This process is repeated at intervals until the coördinates of from 10 to 30 points are determined. In the diagram shown in Fig. 15, the coördinates of 18 points were found in each diagram.

153 The coördinates of *P* and *V* are then plotted on logarithmic cross-section paper, as shown in Fig. 9, which are the logarithmic diagrams derived from the *PV*–diagrams of Fig. 15. The points plotted in Fig. 15 are taken from the columns headed Cu. Ft. at the pressures shown. A smooth curve is drawn through the points thus plotted, and the diagram is in shape to be studied.

TABLE 6 CONSTRUCTION OF THE LOGARITHMIC DIAGRAMS OF TEST 30 †

Number	Head End					Crank End				
	Absolute Pressures, Lb. per Sq. In.	Volumes				Absolute Pressures, Lb. per Sq. In.	Volumes			
		In.		Cu. Ft.			In.		Cu. Ft.	
		Compression* X to A	Expansion* Y to B	Compression	Expansion		Compression	Expansion	Compression	Expansion
1	133.0	0.39	1.18	0.156	0.470	134.3	0.30	1.205	0.115	0.4605
2	113.4	0.31	1.36	0.124	0.5425	115.3	0.28	1.39	0.107	0.531
3	95.0	0.31	1.625	0.124	0.649	96.3	0.28	1.65	0.107	0.6305
4	76.3	0.31	2.02	0.124	0.8055	77.3	0.28	2.06	0.107	0.7875
5	57.1	0.31	2.705	0.124	1.080	58.1	0.295	2.76	0.113	1.055
6	38.9	0.375	4.03	0.150	1.610	38.7	0.385	4.12	0.147	1.572
7	29.4	0.48	4.22	0.192	1.685	29.1	0.485	4.26	0.185	1.626
8	19.5	0.70	4.26	0.279	1.699	19.8	0.66	4.20	0.252	1.600
9	15.0	1.10	3.06	0.439	1.220	15.0	0.93	3.77	0.355	1.440

* Letters refer to Fig. 15, Crank End.

† Final results given in Table 1.

	Head End	Crank End
Length of indicator diagram, in.	3.95	3.99
Ratio of clearance to piston displacement, same end	0.0789	0.0704
Length on diagram proportional to clearance ratio, in.	0.312	0.281
Length of diagram, plus clearance, in.	4.26	4.27
Piston displacement (cylinder 12.02 in. by 24 in.), cu. ft.	1.575	1.523
Clearance volume, cu. ft.	0.124	0.107
Displacement plus clearance, total volume, cu. ft.	1.699	1.630
Ratio, cu. ft. per in. of length on diagram, cu. ft.	0.399	0.382
Scale of indicator spring per in. of ordinate, lb.	77.0	79.0

154 *Examples of Logarithmic Diagrams from Various Types of Engines.* The logarithmic diagrams obtained by plotting the indicator diagrams as already described, are of a distinctly different form from either the *PV*–diagram or the temperature-entropy diagram. While the various typical forms of *PV*–diagrams assume rather different forms after plotting, yet the resultant figures retain in a general way the peculiar characteristics of each *PV*–type except that these peculiarities are exaggerated.

155 Various typical *PV*–diagrams are given in Figs. 16–25, which include examples from many types of engines using steam, gas, air and ammonia as the

active media. The values of n for the curves are given in each figure and it will be noted from these diagrams how closely the law $PV^n = C$ holds for the expansion and compression curves from a great variety of engines using different media.

156 It has long been known that adiabatic expansion, or compression, of any elastic medium takes place substantially according to this law with the different values of n for different media. In practice, however, expansion is never adiabatic, but is changed in character by the presence of the metal surrounding the working medium, and by imperfection of mechanism. The question then arises as to how this expansion has been changed in character and whether it still obeys the law $PV^n = C$.

157 Many investigators have examined the curves from actual diagrams to clear up this point for steam.[1] These include those who find that expansion in steam cylinders takes place substantially according to the law $PV^n = C$, but that n varies in value between wide limits in different cases.

158 An examination was made of the curves of 296 diagrams from the cylinders of 47 different engines using steam, gas, air and ammonia to investigate this point. As a result, it may be stated that, in the cases of the great majority of engines using elastic media, expansion and compression take place substantially according to the law $PV^n = C$. Certain exceptions, however, have been found, and the cases studied.

159 *Cases where the Law $PV^n = C$ does not hold.* The curves of expansion and compression, obtained from PV-diagrams, do not always follow the law $PV^n = C$. This fact is due to several causes, some of which have been definitely determined:

160 (*a*) *Wrong Clearance, or Wrong Location of the Zero Line of Pressure.* The law, $PV^n = C$ is only true where P and V are measured in absolute units. The clearance must be accurately determined in order to give absolute values of V. The scale of the spring, for the PV-diagram analyzed must be known, and also the atmospheric line drawn by the indicator, in order to locate the zero line of pressure. The units used for P or V may be of any denomination, but they must be measured from the zero of P and V.

161 When a curve $PV^n = C$ is plotted on logarithmic paper, the resultant curve is a straight line. The value of n as already explained, is the slope of this line measured from any two points. When the values of P and V are not absolute values, this curve is no longer a straight line, but becomes a curve of the second degree. The value of n being the slope obtained from two points on this curve, is no longer constant for all parts of the curve, but varies from point to point.

162 Therefore, when PV-diagrams are transformed to logarithmic diagrams, the values of both P and V must be measured in absolute units. When these values are not in absolute units, the resulting curve is not of the form $PV^n = C$, and therefore is not a straight line on logarithmic paper. The form of the curve obtained, when the values of V alone are not in absolute units, is given in Fig. 10-b.

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[1] Technical Thermodynamics, Zeuner, vol. 2, p. 111.

Recherches experimentales, Leloutre, Bulletin de la Société industrielle du Nord de la France 1874.

Zur Theorie des Indikatordiagrammes, Luders, Zivilingenieur, 1881, vol. 27, p. 225.

The Steam Engine, Perry, p. 106.

163 (*b*) *Leakage.* The law $PV^n = C$ is applicable only in cases where the weight of the working medium remains practically constant during any expansion or compression. When this weight changes materially either by leakage into, or out from, the cylinder containing the medium the resulting curve no longer obeys the law, and it becomes a curve in the logarithmic diagram. This fact is very clearly shown in the curves of the logarithmic diagram derived from cylinders in which large leaks were known to exist. The examples showing this condition have already been discussed.

164 (*c*) *Low Speed in Steam Engines.* Very low speeds of rotation, together with very low piston speeds, will cause the compression curve to deviate from the law $PV^n = C$. The most common cases of this effect are seen in the "hook" or excessive condensation, near the upper end of compression curves. These hooks are found almost altogether in small engines having very low piston speeds, and in larger engines with small clearance, having very low rotational speeds, as in pumping engines.

165 Diagrams containing hooks in the compression curves have been published by Professor Dwelshauvers-Dery[1] from the experimental engine at Liege. This is an example of a very low speed in a small engine. The size was 12 in. by 24 in. and the speed from 30 to 60 r.p.m. That this hook was caused by low speed and consequent excessive condensation, was proved in a measure in the case of the engine used by the author. This engine was also 12 in. by 24 in. but was operated at from 90 to 150 r.p.m. In no case was a hook in the compression curve obtained during the tests, although some 1600 diagrams were taken. A set of diagrams from these tests is shown in Fig. 15, and shows no sign of a hook. On one occasion, however, the diagram shown in Fig. 26 was obtained. This was taken just after the engine was started from cold, and had been brought up to a speed of 120 r.p.m. In conjunction with the other diagrams obtained from this engine in regular operation, this hook is believed to be due to excessive condensation while the cylinder was comparatively cold.

166 The three causes just treated are believed to be the important conditions that cause the curves in practice to depart materially from the law $PV^n = C$. Sometimes only one of these conditions is present, while in other cases, a combination of these may influence the resulting curves. The separation of these conditions by their effect on the curves has already been treated.

PART 2 PRINCIPAL DIMENSIONS OF ENGINE USED IN TESTS

a Type—Horizontal single-cylinder, double-eccentric, non-condensing, variable speed, heavy-duty frame, Reynolds Corliss engine

b Class—Belt drive for mill work

c Maker—Allis-Chalmers Company, Milwaukee, Wis.

d Rated Power of Engine—100 h.p. at 115 lb. initial pressure above atmosphere on indicator diagram, $\frac{1}{4}$ cut-off, and 120 r.p.m.

e Cylinder dimensions

a Bore (measured while hot), in	12.02
b Stroke, in	24.00
c Diameter of piston rod, in	$2\frac{3}{16}$

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[1] Power, June 28, 1910, p. 1165.

f Clearance—In per cent of volume displaced by piston per stroke

a Head end	7.89
b Crank end	7.04

g Speed—Controlled by fly-ball governor with variable gear ratio between main shaft and governor, giving any engine speed from 20 to 160 r. p. m. Ususal speed 120 r.p.m.

167 The cylinder of the engine is not steam-jacketed on the ends but is partly jacketed on the barrel by the steam chest, the latter covering about one-sixth of the barrel surface. The exhaust passages are separated from the lower part of the cylinder barrel by a dead air space formed in the cylinder casting.

THE REDUCTION IN TEMPERATURE OF CONDENSING WATER RESERVOIRS DUE TO COOLING EFFECTS OF AIR AND EVAPORATION

By W. B. Ruggles

ABSTRACT OF PAPER

The tests described in this paper were made to determine the heat radiation from a cooling reservoir of about 6½ acres, at the Crescent Portland Cement Company's plant at Wampum, Pa. The amount of heat delivered to the reservoir from the engines and compressors was measured by hourly readings for power and vacuum and the reduction of temperature, due to pumping in fresh water from the Beaver River, and by rain was also taken. By frequent readings of temperature of tail water, intake water and air, the cooling effect of the air on a unit of surface of water per unit of difference of temperature was easily determined.

THE REDUCTION IN TEMPERATURE OF CONDENSING WATER RESERVOIRS DUE TO COOLING EFFECT OF AIR AND EVAPORATION

By W. B. Ruggles, New York
Member of the Society

The tests described in this paper were made with the idea of determining if possible, a fairly reliable factor by the use of which the necessary size of a cooling reservoir for condenser water could be predetermined for any assumed power and weather conditions.

2 In 1908, while designing the mill for the Crescent Portland Cement Company at Wampum, Pa., it was found necessary to install a cooling device for the condensing water from the engines. The mill stands on a level plateau about 110 ft. above the Beaver River and to pump water from the river for condensers meant a considerable expense for power. On the side of the plateau furthest from the river was a natural depression alongside the Erie division of the Pennsylvania Railroad which offered a desirable location for a reservoir (Fig. 1). After a diligent search, no data were found as to how large a reservoir had to be to give the necessary cooling effect to the water, so that it might be used continuously. A dam, however, was built 275 ft. long and 18 ft. high, of skeleton reinforced concrete construction which would impound about 6½ acres of water (Fig. 2).

3 Three tests were made during the year 1911, each of one week's duration in order to determine the heat radiation from the surface of the reservoir. These tests were made in May when the temperature was moderate, in July when the temperature was high and in November when the temperature was low. Readings were taken of the temperature of the river water, the intake water to the power house, the tail water from the condenser and of the air. The vacuum,

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The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

the power, the amount of water pumped from the river to the reservoir, and the rainfall were also recorded. These data were taken by James Toler, Chief Engineer of the Crescent plant and by the writer's assistant, John E. Mason. Unfortunately the temperature of the rain was not taken, but it has been assumed the same as the temperature of the air, so that the figures for that are only approximate, but a difference of 10 deg. in the temperature of the rain would not alter the result by more than $\frac{2}{10}$ per cent.

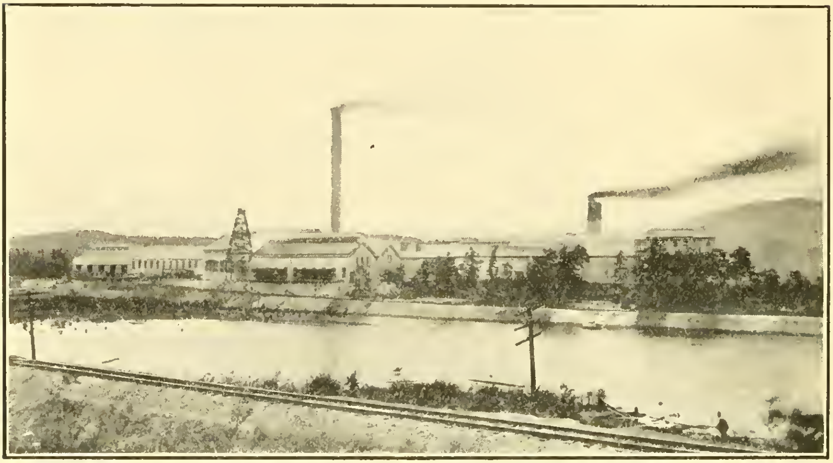

Fig 1 View of the Crescent Portland Cement Company Plant Showing Reservoir

4 The engines used in the power house are three Ball and Wood compound condensing engines, 26 in. by 52 in. by 36 in. The air compressors are two compound Laidlaw-Dunn-Gordon compressors, the steam cylinders of which are 12 in. and 21 in. in diameter respectively, the air cylinders 11½ in. and 24 in. respectively, the stroke 24 in. The steam from all of these is condensed in an Alberger barometric condenser equipped with a dry vacuum pump and the circulating water supplied by a direct-connected centrifugal pump driven by a synchronous motor; an engine-driven circulating pump and a second dry vacuum pump being installed as reserve.

5 The water from the condenser flows about 50 ft. through a tile pipe into the east side of the reservoir about 100 ft. from the north end. A dike was built south of this inlet to the reservoir extending about 50 ft. toward the center of the reservoir and then

north nearly to the north end. This compels the circulating water to flow up and around the end of this dike and down toward the dam, a distance of about 1100 ft., before it reaches the intake to the power house.

6 Water to supply the reservoir is pumped from the river by a centrifugal pump direct connected to a 150-h.p. motor. The pump delivers an average of 2324.25 gal. of water per minute and it is found that about 8 hours pumping per week is sufficient to make up for the evaporation and seepage in the reservoir. The water from the river pump is delivered into an open well situated on top of the plateau where the mill is located. It flows by gravity from this well through a 24-in. tile pipe into another concrete well located in the reservoir about 800 ft. north of the dam. From this well it flows through a No. 24 tile pipe laid on the bottom of the reservoir to within 6 ft. of the dam. The intake water for the boiler feed and condenser is drawn from this well so that the water must flow up through the concrete tile pipe from the bottom of the reservoir at its deepest point. While water is being pumped from the river, there is a flow south through this tile pipe and when not pumping, the water is drawn in the opposite direction through it.

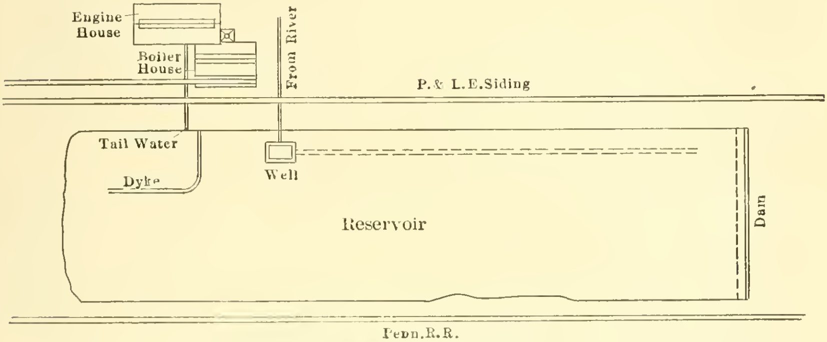

FIG. 2 DIAGRAM SHOWING 6½-ACRE RESERVOIR AND CONNECTIONS

7 The average horsepower developed in the engines during the 21 days of these tests was 2446. Incidentally, it may be stated that there was an average of 3062 bbl. of cement manufactured per day during the same test, or 1 bbl. of cement for 0.8 h.p.

8 The results of the tests during these three weeks are as uniform as could be expected; the heat lost per square foot of surface being slightly less per 1 deg. difference of temperature in cold weather than

in warm weather. This difference is undoubtedly due to an increased amount of evaporation during the warmer period.

9 The average humidity for the different weeks during which the tests were made was 58.5 per cent in May, 62.3 per cent in July and 71.2 per cent in November.

10 Table 1 gives the results in detail of the tests made.

TABLE 1 TEST OF HEAT RADIATION FROM SURFACE OF CONDENSER WATER RESERVOIR AT PLANT OF CRESCENT PORTLAND CEMENT CO., WAMPUM, PA.

Area of reservoir, 288,000 sq. ft.; average depth of reservoir, 5.36 ft.; capacity of reservoir, 1,543,680 cu. ft. = 96,480,000 lb.

Date of Tests	Week ending May 7, 1911.	Week ending July 12, 1911	Week ending November 27, 1911.
Amount of water pumped from river, lb.	10458956	29050875	4648140
Average temperature of river water, deg. fahr	57.5	77	36
Average temperature of intake to power house, deg. fahr	72.75	91.43	61.71
Average temperature of tail water from condenser, deg. fahr	101.36	129.43	90.71
Average temperature of reservoir, deg. fahr	87.05	110.00	76.71
Average temperature of air, deg. fahr.	51.00	78.43	33.30
Average difference of temperature between water and air, deg. fahr	36.05	31.57	43.41
Change in temperature of reservoir during test, deg. fahr	0.25	7.00	2.00
Three 26 in. by 52 in. by 36 in. compound condensing engines, h. p-hr	397807	411320	426936
Two 12 in. by 21 in., 11½ in. by 24 in. by 24 in. air compressors, h.p-hr	46536	46536	46536
Average vacuum at 30 in barometer, in.	26.4	22.2	26.6
Average water consumed by engines, per h.p. per hr., lb	14.46	15.64	14.41
Average water consumed by compressors per h.p. per hr., lb	18.85	20.12	18.83
Steam condensed by engines, lb	5752289	6433045	6145148
Steam condensed by compressors, lb	877204	936314	876273
Latent heat of steam condensed, lb	1024.7	1007.1	1026.0
Heat delivered to reservoir by engines, b.t.u	5894370000	6478720000	6304922000
Heat delivered to reservoir by compressors, b.t.u	898871000	942961000	899056000
Heat to raise river water to average temperature of reservoir, b.t.u	309062000	958679000	189226000

TABLE 1—*Continued*

Date of Tests	Week ending May 7, 1911	Week ending July 12, 1911	Week ending November 27, 1911
Heat given up or retained in reservoir during test, b.t.u	24120000	675360000	192960000
Heat reduction in reservoir due to rain, b.t.u	21630000	56700000	46200000
Heat absorbed by air and evaporation during seven days, b.t.u	6438429000	5730942000	6564509000
Heat absorbed by air and evaporation. per sq. ft. of surface seven days, b.t.u.	22356	19899	23495
Heat absorbed by air and evaporation per sq. ft. per hr., b.t.u	133.1	118.4	139.8
Heat absorbed by air and evaporation per sq. ft. per hr., per 1 deg. difference b.t.u	3.69	3.71	3.22

11 It appears from the tests that under ordinary conditions, in the northern part of the United States with engines using 15 lb. of water per h.p-hr. and a vacuum of 26 in., a reservoir having a surface of 120 sq. ft. per h.p. would be ample for cooling and condensing water.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

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FOREIGN REVIEW

The aim of the Foreign Review is to present, within the available space, the main data contained in the articles indexed. Where possible, reference is made to English or American publications containing fuller information on the subject treated. Measures are given both in original units and their English equivalents. In many instances, engravings and tables are reproduced. Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer.

Aeronautics

LES NOUVELLES EXPÉRIENCES DE M. EIFFEL AU LABORATOIRE DU CHAMP-DE-MARS. *L'Aérophile*, February 15, 1912. 5 pp., 13 figs. *e*. An account of various *experiments of Eiffel on air resistance.* The article is an abstract of Eiffel's book, La résistance de l'air et l'aviation, published in Paris last year.

Air Machinery

TOURBO-SOUFFLANTE DE GRANDE PUISSANCE POUR ACIÉRIE. *Le Génie Civil*, February 10, 1912. 1/2 p. *d*. Description of a *turbo-blower* installed by the Brown, Boveri Company of Baden, Switzerland, at the plant of the Metallurgical Company of Sambre and Moselle, at Montignies-sur-Sambre, France, to supply the draft for four 15-ton Bessemer converters. The blower is able to compress from 150 to 800 cu. m. (5300 to 28,250 cu. ft.) per minute to pressures from 0.4 kg/qcm (5.6 lb. per sq. in.) to 2.5 kg/qcm (35.5 lb. per sq. in.). The blower is driven by a turbine of 3750 maximum h.p., and has the maximum speed of 2600 r.p.m. In comparison with reciprocating blowers, the turbo-blower is remarkably compact: the foundations occupy only 38 sq. m. (406 sq. ft.), while a reciprocating blower would occupy about 168 sq. m. The expenses of upkeep and lubrication are said to be very low, while the regularity of operation materially increases the efficiency of the converters, and makes unnecessary the use of air-pressure regulators in the tuyeres. When no blowing is required, the blower rotates at about 800 r.p.m.; when the signal for blowing is given, the pressure is raised to 1.9 kg/qcm (27 lb. per sq. in.) in about 10 to 15 seconds; at the end of the blowing the pressure is raised to 2 or 2.5 kg/qcm (28.4 or 35.5 lb.

per sq. in.). The pressure and quantity of air delivered is regulated with perfect certainty by changing the speed of the blower, no auxiliary pumping being required at the beginning.

Brakes

NEUE BREMSEN, INSBESONDERE FÜR GIESSEREIKRANE, Wintermeyer. *Giesserei-Zeitung*, February 1, 1912. 2½ pp., 3 figs. *d.* Description of new *brakes for foundry cranes*, both for single-phase asynchrone and for two-phase motors.

Fuel

EINE NEUE BRIKETTPRESSE. *Braunkohle*, February 9, 1912. 3½ pp., 6 figs. *d.* Describes a new type of briquette press built by Ehrhardt and Sehmer, in Saarbrücken, Germany. The crankshaft is supported by bearings belonging to the body of the press, and carries on one of its ends the fly-wheel, and on the other the disc-crank and crank-pins of the steam engine, the press-rod being connected to it in the middle. The press-rod has a forced-feed lubrication, with the surface pressure so slight that no water cooling is necessary. The valve gear of the steam engine is arranged as follows: the admission valves are at the top of the steam cylinder, actuated by a wedge-gear, its reciprocating motion being transmitted to it from an eccentric on the engine-shaft by a rocking lever and rod. The valve gear is positive, and the valves open and close rapidly, but with a somewhat softer motion in closing. The exhaust is placed on a side at the bottom of the steam cylinder, so as to let out absolutely all the water of condensation, and is actuated, independently of the admission valve, by a piston valve of special construction. The advantages of this press are: there is only one fly-wheel; the bearings for the crankshaft and the main pressure rod are easily accessible; no spur or bevel wheels, and many less bolts are used, the gear transmission being throughout by means of eccentrics. One of the illustrations shows how a press of the older type is changed to this construction.

VERWERTUNG DER MOORE DURCH GEWINNUNG VON KRAFTGAS UND AMMONIAK, A. Frank. *Journal für Gasbeleuchtung*, January 20, 1912. 4 pp. *p.* An account of the work of the Hannoversche Kolonisations- und Moorverwertungsgesellschaft, which bought about 1000 ha (2471 acres) near Osnabrück, Prussia, and are producing *electric current by producer-gas engines* from power-gas obtained from Mond generators, *with peat as fuel.* For 1000 h.p. per year, produced at the rate of 8000 h.p. per hour, the consumption of peat is taken to be about 4 ha (9.88 acres), the layer of peat being 3 m. (9.8 ft.), and a ton of dry peat producing at least 650 to 700 h.p-hr. The soil from under the peat is treated in the same manner as in Holland and converted into high grade agricultural land. Power gas can be obtained from peat containing as much as 50 to 55 per cent of water, the gas having about 1400 WE (160 b.t.u. per cu. ft.). With higher content of water, both the content of carbon dioxide and volume of gas rose, but heat content decreased. An amount equal to 2.4 cbm (84.7 cu. ft.) per effective horsepower of the normal gas (i. e. obtained from peat with water content not above 55 per cent) was required. As a by-product, about 40 kg. (88 lb.) of ammonium sulphate per ton of dry peat was obtained.

Internal Combustion Engines

IL PETROLIO NELLA NAVIGAZIONE. *L'Elettricista*, February 15, 1912. 1¼ pp. *g.* Discussion of the *use of oil fuel in propulsion of vessels* and description of the vessel Vulcan propelled by Diesel engines built for the Danube trade for the Astra Romana Co. The article is based on one by L. Erbiceanu in the *Monitore del petrolio rumeno*, August 2, 1911. The tank-ship Vulcan for the transport of oil was built in Amsterdam, Holland, and equipped with a 6-cylinder, 4-cycle, 500 h.p., Diesel engine, with a vertical compressor delivering air at 60 kg/cm (853 lb. per sq. in.) pressure. The motor can be reversed by a hand lever, the engine being previously stopped, and the whole time necessary for this operation does not exceed 20 seconds. The consumption of oil (Roumanian) was found to be about 0.2 kg (0.44 lb.) per h.p-hr., at a normal speed of 8 miles per hour. The operation of the motor proved to be satisfactory, noise not excessive, but vibration more noticeable than in the case of a steam engine.

SEEFISCHEREI-MOTOREN, F. Romberg. *Dinglers Polytechnisches Journal*, February 3, 1912. (Cp. The Journal, March 1912, p. 411). *d.* End of a series of articles on the *design of motors for fishing craft.* For a detailed abstract see *Engineering*, March 1, 1912.

WIEDER EINE EXPLOSIONSTURBINE. *Der praktische Maschinen-Konstrukteur*, February 1, 1912. 1 p., 1 fig. *d.* Description of a *gas turbine* lately built by F. J. E. Johansson in Stockholm, Sweden. This turbine has a number of explosion chambers placed side by side, each provided with two admission and one exhaust valves which are so arranged that when an exhaust valve opens in one chamber, it throws open the admission valve in the next, and permits it to be filled with an explosive mixture. For a complete translation of this article see *The Automobile*, March 7, 1912.

DER BRÜNN-KÖNIGSFELDER GLÜHKOPF-ZWEITAKTMOTOR, Ernst Neuberg. *Die Gasmotorentechnik*, February 1912. 7 pp., 12 figs. and 1 plate of drawing. *d.* Description of the *Brünn-Königsfelder two-cycle motor.* The author divides all internal-combustion engines into two classes: those above 15 h.p., and those below. The man who buys a small engine, say of 5 h.p., will probably in about two years, as his business grows, need an 8-h.p. one, and in about two more years a 12-h.p. He will therefore from time to time come to the place where he bought the engine, and want to have it exchanged for a larger one. The man who buys a large engine, say of 100 h.p., when he wants more power, will as a rule not exchange his engine for a larger one, but buy another. Wtih the buyer of the small engine the intial cost is therefore a primary consideration, while in selecting a large engine more attention is paid to cost of operation and yearly amortization required. In the first case therefore small engines have to be as cheap as possible, while in the second a good deal more attention is paid to workmanship. The following are the principal characteristics of the two classes:

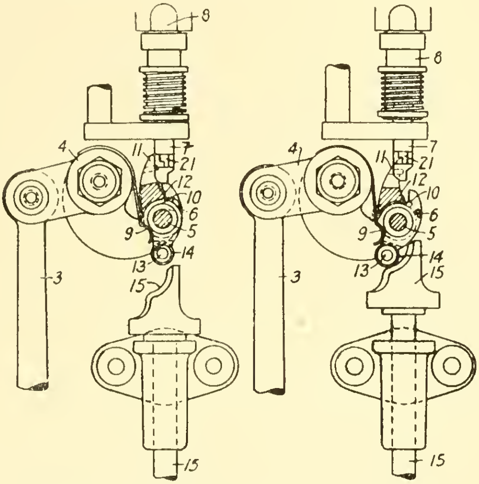
	FIRST CLASS.	SECOND CLASS
Lubrication	Forced lubrication for the crank bearings, crank pin, piston pin, and cylinder, wick oiling being used only for thrust bearings in motor boats.	Forced lubrication for the cylinder and piston pin. Wick oiling for crank and thrust bearings in motor boats. Bearings with oil rings for the main bearing of crankshaft in stationary motors.
Governing	Centrifugal governor regulating the supply of combustible in proportion to power required.	Same as in First Class.
Starting	The flywheel is rotated through half a revolution by hand.	Without compressor by air pressure of 8 to 10 atmospheres, the compressed air being replaced from the working cylinder.

The article proceeds to describe in detail the system employed by the factory to standardize the production as far as possible. This system is based on the same principle as that described in The Journal, January 1912, p. 132. The details of specifications of various types of engines are also described.

The reversing of the motor-boat type of these engines is arranged as follows: The fuel pump is under the influence of two governors: the centrifugal governor regulating the speed of the engine, and a second, inertia, governor which begins to act at reversing, and only when the speed has gone down considerably. The action of the reversing lever produces therefore the following effects: (*a*) it cuts out the centrifugal governor and the fuel pump; (*b*) it cuts in the inertia governor which forces the pump to deliver to the engine two or three times as much fuel as before, the speed being considerably decreased, and at an earlier moment than usual; this leads to a premature explosion which reverses the direction of rotation; (*c*) it then cuts out the inertia governor, and cuts in the centrifugal governor and fuel pump.

Figs. 1 and 2 show in detail the contruction of the single-cylinder motor. On the motor-shaft is placed a centrifugal governor of the usual construction which acts on the eccentric whenever the speed or output of the motor is changed. This eccentric is connected by the rod 3 with lever 4 in such a way that the amplitude of the lever changes with the change in the travel of the eccentric. The catch 6 on pin 5 of lever 4 transmits the motion of the lever to the plunger 7 of the fuel pump 8, so that an increase in the travel of the eccentric causes an increase in the amplitude of the lever, and that leads to a greater swing of the plunger in the fuel pump, and larger supply of fuel. The spring 9 and stop-pin 10 serve to keep the catch 6 in place. On the pin 5 is also the catch 11 of the inertia governor, the projections 12 preventing the catch 11 from moving to the right and thus engaging with the plunger 7. These figures show the position of the parts for the normal action of the motor.

Perfectionnement des moteurs à combustion interne par le rechauffage préalable de l'air, A. Nougier. *Le Génie Civil*, February 24, 1912. 3 pp., 1 fig. *dtA*. Beginning of a series of interesting articles on the *use of preheated air in internal-combustion engines* of the Diesel type. The incentive to seek for an engine which would economically burn heavy oils was due to the heavy duty on petroleum in France, making the use of ordinary Diesel engines very uneconomical. Carels Brothers in Gand, Belgium, tried to get around this by feeding their engines with tar-oil, but injecting some petroleum before the end of the compression stroke, thus using the petroleum as a sort of ignition for the tar-oil. This necessitated, however, the installation of a double valve gear, and so complicated the working of the engine that it had to be given up. Aside from the comparative cost of petroleum and heavy oils a system that would permit of doing away, even partly, with the high compressions used in the Diesel engine would be of great advantage by dispensing with the air compressor which increases the first cost of the engine and takes as much as 7 per cent of the power delivered to the engine shaft, and by making less important than at present the great strength of the cylinders and elaborate arrangements for keeping them and the valves thoroughly air tight. The author claims that this can be done by *preheating the air drawn into the engine*. He bases his claim on the principle that *a slight increase in temperature of the air at the beginning of the compression stroke results in a large increase of temperature at its end*, and proves it in the following way: Since pure air is practically a perfect gas, and the compression practically adiabatic, either of the following three equations must hold:



Figs. 1 and 2 Brünn-Königsfelder Two-Cycle Motor

$$\frac{p_1 v_1}{T_1} = \frac{p_o v_o}{T_o} \dots\dots\dots\dots [1]$$

$$p_1 v_1^{1 \cdot 41} = p_o v_o^{1 \cdot 41} \dots\dots\dots\dots [2]$$

$$p_1^{0 \cdot 71} v_1 = p_o^{0 \cdot 71} v_o \dots\dots\dots\dots [3]$$

By dividing, member by member, [1] by [2], the relation

$$T_1 = T_o \left(\frac{v_o}{v_1}\right)^{0 \cdot 41} \dots\dots\dots\dots [4]$$

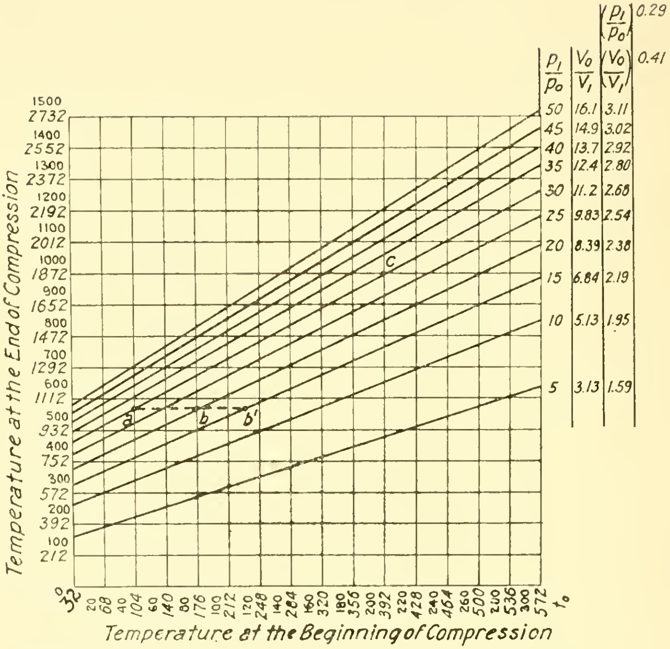


Fig. 3 Adiabatic Compression—Rise of Temperature Curves for Air

The small, vertical figures indicate deg. cent.; the larger, inclined figures, deg. fahr.

is obtained which gives the final absolute temperature T_1 of air taken at initial absolute temperature T_o and subjected to adiabatic reduction of volume $\frac{v_o}{v_1}$.

By dividing, member by member, [1] by [3], the relation

$$T_1 = T_o \left(\frac{p_1}{p_o}\right)^{0.29} \dots\dots\dots\dots [5]$$

is obtained which gives the final absolute temperature T_1 of air taken at initial absolute temperature T_o and subjected to adiabatic compression $\frac{p_1}{p_o}$. Fig. 3 gives a set of curves expressing the relations [4] and [5] for certain values of $\frac{v_o}{v_1}$ and $\frac{p_1}{p_o}$. For each given value of $\frac{v_o}{v^1}$ or $\frac{p_1}{p_o}$, equations [4] and [5] represent straight lines, and all these straight lines meet at a point having the coördinates −273 and

−273 (deg. cent.). The third row of figures on the upper right corner indicates the values of $\left(\frac{p_1}{p_0}\right)^{0.29}$ or $\left(\frac{v_0}{v_1}\right)^{0.41}$ which would be equal to the angular coefficient of the line if the scale of the abscissæ were equal to that of the ordinates. This graph facilitates the obtaining of the final temperature t when the initial temperature *to* and adiabatic compression is known and can be expressed either in the form of $\frac{p_1}{p_0}$ or as $\frac{v_0}{v_1}$. Thus, if the initial temperature of the air was 40 deg. cent. and it was compressed to 30 atmospheres, its final temperature will be 566 deg. cent.; but the same temperature may be attained by compressing the air to only 10 atmospheres, after preheating it to 80 deg. cent., and of course it is much cheaper and easier to preheat the air by the exhaust gases, than to subject it to very high compression which cannot be done without the consumption of power.

An interesting peculiarity of this process is that it can be applied to existing motors by changing slightly the injection and valve gear, and thus adapting them to running on cheaper fuels.

There is, however, a limit to the heating of air beyond which it ceases to be of advantage, since, the volume of air admitted to the cylinders being constant, its *weight* will decrease as the temperature rises, and finally a point will be reached when the weight of air admitted will not suffice to insure complete combustion. The article is to be continued.

Neuere Rohölmotoren, Ch. Pöhlmann. *Dinglers Polytechnisches Journal*, February 10, 1912. 6½ pp., 16 figs. *d*. Further description of the *latest types of oil engines*. To satisfy the demand for a comparatively *cheap and compact high-speed machine*, the M. A. N. Co. has lately placed on the market a special type built in sizes from 25 to 250 h.p., with two, four, and six cylinders, and piston speed of 3.5 to 4.5 m (11.5 to 14.8 ft.) per second. The largest unit built, a four-cylinder 1000-h.p. engine, has a cylinder diameter of 660 mm (26 in.), and stroke 720 mm (28 in.), and makes 187 r.p.m. All the high-speed engines are made with box-pattern engine beds; the air pumps are placed on the engine bed, and are driven direct from the crankshaft. The pistons of this motor are provided with adjustable blocks, with white metal lining to take care of the play that may be produced by the wear of the piston. The lower part carries the guide block, and the upper all the piston rings, while between the two is a caulking ring permitting the exact regulation of the height of the compression chamber. This arrangement considerably simplifies the manufacture of the pistons since the upper and lower parts may be made in standard sizes, and only the caulking ring has to be individually adjusted for each engine. The upper part of the cylinder is provided with a double deck and oil cooling; the lubrication is by forced feed. Notwithstanding very careful workmanship, the high-speed oil engine has not so far proved an unqualified success. While in operation, the rapidly moving imperfectly balanced machine parts set up powerful vibrations which transmit themselves to the buildings in an undesirable manner. Six-cylinder engines permit perfect balancing, but in four-cylinder engines the foundations must be exceptionally strong, even when the cranks are placed at 90 deg. to each other, which appears to be better than with cranks arranged symmetrically in the middle of the engine. On the whole, the author thinks that stationary high-speed oil engines are not yet "ripe for the market."

NEUERE ROHÖLMOTOREN, Ch. Pöhlmann. *Dinglers Polytechnishes Journal*, February 24, 1912. 2 pp., 5 figs. *d.* Description of the *Diesel motors* built by Sulzer Brothers in Winterthur, Switzerland. This concern used to build its high-speed Diesel engines with a horizontal compressor, but gave up this practice lately, and now uses a normal three-stage vertical compressor.

GENERATOREN ZUR VERGASUNG VON KOKSLÖSCHE BZW. KOKSGRUS, Meyer. *Journal für Gasbeleuchtung*. January 27, 1912. 7 pp., 12 figs. *d.* Cp. NEUE GASERZEUGER FÜR FEINKÖRNIGE ODER STAUBFORMIGE BRENNSTOFFE, GWOSDZ. *Elektrotechnischer Anzeiger*, February 11, 1912. 2 pp., 4 figs. *d.* Cp. The Journal, March 1912, p. 413. Both articles describe gas producers for small coal, mainly on the basis of the practice of the Julius Pintsch Company, the first treating particularly the problem of burning coke waste and coke dross, as well as cinders from locomotive smoke-boxes. The processes and gas producers described have been thoroughly tested in European practice where there are many plants of considerable capacity (over 1000 h.p.) working on this kind of fuel.

Coke waste from gas plants is of fairly large and regular grain, and can be utilized in ordinary shaft producers. Cinders from locomotive smoke-boxes, especially those using good pit coal, are of comparatively large grain, 2 to 4 mm (0.078 to 0.157 in.), while coke dross from coke ovens is generally of very small grain; both have to be burned in specially constructed producers, and can then give 1 h.p-hr. for 0.8 kg (say 1¾ lb.).

The article contains descriptions, in order of historical development, of the types of producers constructed by the Julius Pintsch Company for small grained coal, of which the following are the latest types and deserve particular attention: Fig. 4 shows a clinker-melting producer. The air for combustion is introduced through tuyeres at such a rate that the clinkers melt, and can then be tapped off from below. The main trouble with this type of producers is that small coal, say under 1.5 mm (0.06 in.), is carried away with the stream of gas, due to the high velocity of gases which have to be maintained in the zone of combustion. A better type for use where regularity of work is essential is therefore the step-grate producer (Fig. 5). The fuel must be introduced from above, and the producer provided with a loading device arranged in such a manner that the fuel may be introduced inside without letting the air in. The material is heaped against the step-grate, and by a suitable design of the producer this heaping may be regulated so as to give the most advantageous region of gasification for each material, according to its grain. A zone of incandescence is produced above the grate, the gases pass through the whole depth of fuel layer, and leave the generator at the top. A special system of air regulation allows the opening of the ash pan without affecting the gas production. The gases which come from the producer are led through an evaporator, and there produce steam of very low pressure (1 to 1.5 m, or

40 to 60 in., of water) which passes to a jet blower and drives into the producer as much air as is required for the gasification, thus making the air and steam mixture constant. The advantage of this construction consists in the ability to remove the ashes and clinkers from the grate without in any way interfering with the action of the producer. The size of these producers has to be fairly large, and there is an advantage in building them round. Fig. 6 shows an arrangement for getting rid of the tar in the fuel. The gas in going from the generator *a* to the tar-separator *b* passes through a scrubber (not shown in the drawing), where it is preheated up to the temperature at which the separation of tar can best take place. The gas then passes to the tar-separator, and is finally driven by an exhauster or ventilator to where it is wanted. There is also a by-pass with a regulator *d* which sends through the tar-separator a full amount of gas even when the load on the engines is suddenly thrown off,

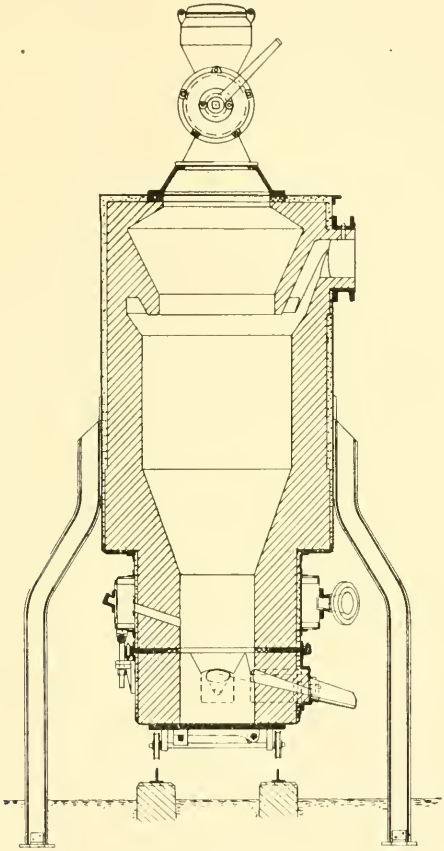


Fig. 4 Pintsch Clinker-Melting Producer

and thus prevents poor separation of tar due to variations in the amount of gas flowing through the separator. The attempt to regulate the action of the separator by drawing the gas bell of the separator in and out did not prove quite successful. The article contains also a description of the Pintsch suction-gas plant, for which see H. Güldner, Design and Construction of Internal Combustion Engines, New York, 1910, p. 275. The article by Gwosd also contains a short description of the Harnisch inclined-grate producer.

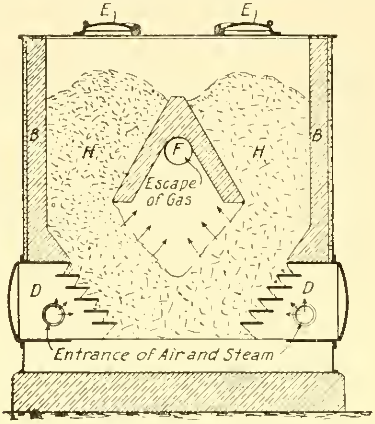
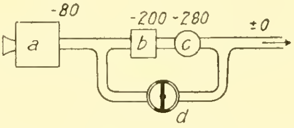


Fig. 5 Pintsch Step-Grate Producer for Small-Grained Coal



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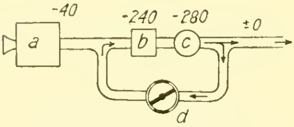

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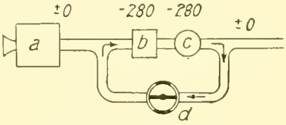

No Load

Fig. 6 Tar Separation Diagram

Uber Automobil- und Gasmotorenschmieröle, F. Schwartz and H. Schluter. *Zeits. des Mitteleuropäischen Motorwagen-Vereins*, Middle February 1912. 4 pp., 2 of which are tables. *c.* Data from *tests of lubricating oils for automobiles and gas engines* made by the Prussian Royal Laboratory for Testing Materials. There is a considerable difference in the behavior of lubricating oils in steam engines and gas or gasoline motors, due to the very high temperature and great piston speed in the latter case, and, although the processes affecting the lubricating oil in an internal combustion engine are as yet but slightly known, there is no doubt but that part at least of the oil is burned up by the sudden fierce heat of the explosion of the mixture. The combustion of the oil is, however, incomplete, and the more so, the more carbon and the more matter boiling only at a high point, contained in the oil. Most of the oxygen in the air drawn in is required for the combustion of the fuel, and if the oil contains more carbon than the remaining unconsumed oxygen can take care of, the extra carbon is not burned up, but forms a residue, and produces undesirable friction and heating up of parts. The products of incomplete combustion in the exhaust are also, as shown by these experiments, the *cause of its unpleasant smell.*

To test in how far the presence of heavy constituents affected the lubricating properties of oils it was necessary to find a method of separating the light from the heavy oils; for this purpose acetone was used, which has the property to dissolve, at room temperature, heavy oils, but leaves light oils unaffected. In tests made with a Benz automobile, the motor was first made to run idle and with excessive lubrication, and then under regular road conditions. When oil treated with acetone was used as a lubricant, and lubrication excessive, thick gray-white clouds were exhausted, but the smell was very faint and by no means unpleasant, while with a normal amount of lubrication there was no smell at all. When ordinary oil, i. e., oil not treated by acetone, was used in the same manner, the familiar unpleasant smell was immediately noticed. It is therefore quite possible to produce a lubricating oil that would do away with the automobile smell. The article contains complete tables of data from the tests, both for automobile and gas engines.

Stehende Hochleistungs-Diesel-Viertaktmaschine der H. Pauksch A.-G., Landsberg a. W. *Die Gasmotorentechnik*, February 1912. 3 pp., 4 figs. *d.* Description of a *vertical high-speed four-cycle Diesel engine* built by the above named concern. For this type of machine with high piston velocity is predicted a promising future because it can be used both for stationary and marine engines. As compared with the present types it has the advantages of lower initial cost, smaller dimensions, and less weight, the last being particularly important for export trade. Its higher speed is of great advantage where the engine may be directly connected to a dynamo, pump, air compressor, etc., a thing that cannot be done with a slow-speed engine at all. Its disadvantage lies in its higher consumption of fuel as compared with the slow-speed engine, the difference in favor of the latter being about 20 grams (0.44 lb.) per h.p-hr. The vertical construction was selected to obtain as quiet and vibrationless action as possible, and for the same reason the engine frame and bedplate were made of cast iron (see Fig. 7).

The high speed of the engine required an installation of a very reliable system of lubrication. The crank bearings have forced-feed lubrication with copper piping, the oil being carried from the crank bearings, through ducts in the shaft and connecting rod, to the crank pin and piston pin bearings, the last being also provided with a special lubrication of its own. All other parts which require lubrication receive it from a central lubricating apparatus with an adjustable number of oil-drops. All the oil after use passes into the crank pit, whence it is driven by a rotary pump, through a condenser coil and a filter working at a pressure of three-quarters to one atmosphere, back to the crank bearings: this arrangement reduces the consumption of oil very considerably.

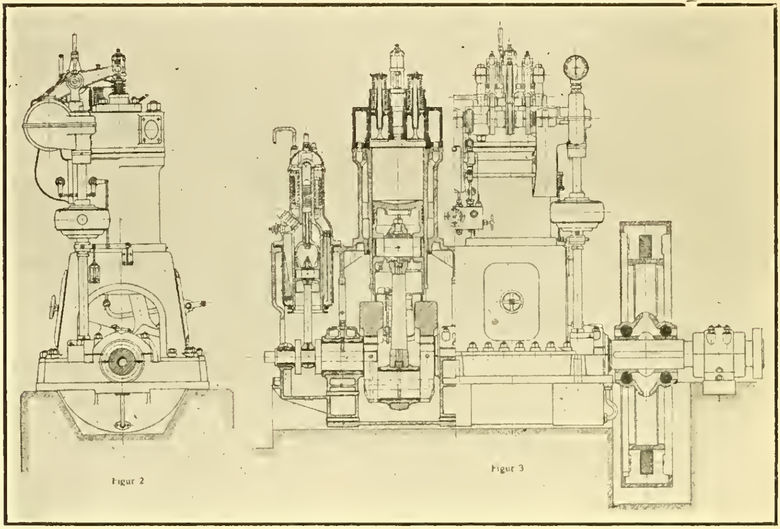

Fig. 7 Pauskch Vertical High-Speed Four-Cycle Diesel Engine

The engine frame is of the usual box pattern, and is cast in one piece with the cylinder jacket. Large openings with door latches provide convenient access to the crank case, the doors on one side forming the point of support of the piston-driven indicator rod. The cylinder liner is protected at the bottom by a cast-in ring of white metal from the action of cooling water that may collect around it. The bottom of the cylinder cover is bell-shaped. This increases its strength and prevents the formation of cracks due to considerable changes in temperature. The discs of the admission and exhaust valves are made very large owing to the great velocity of the air, and therefore are not provided with artificial cooling. Since the valve springs are subjected to very great stresses on account of rapid and powerful variations of compression and tension, valve stems are equipped with two springs of small diameter wire and large diameter of winding. The packing of the valve needle of the fuel valve and its disc atomizer consists only of vulcanized asbestos rings, while the carefully turned spindle of the admission valve has no stuffing box at all. Owing to lack of room, the admission valve had to be placed in the middle of the cylinder cover; the valve lever therefore lies between the forks of the fuel lever, and is provided with two symmetrically arranged rollers corresponding to the divided cam disc. The admission and exhaust cams are laid out on different curves which insures a very quiet running of the lever rollers, notwithstanding the high speed of the engine.

The condenser coils of the two-stage compressor, both of the high and low-pressure cylinders, are laid in the cooling space of the cylinders in such a way that the stream of hot air from the delivery valves goes direct into the cooled pipes. This gives not only a very effective cooling, but materially simplifies the construction of the compressor. The oil filter, a very important part in a high-speed engine, is said to be efficient and reliable, but no details of its construction are given.

Machine Shop

Classification et emploi des métaux dans les ateliers de la Société française de la construction mécanique, J. Netter. *La Technique moderne*, February 1 1912. 2½ pp., 6 figs. *dp.* The great variety of steel used on the French railroads and the insistence on each particular piece being made of the kind of steel satisfying exactly definite conditions of strength, hardness, etc., necessitated the introduction of a system of classification of materials in large French steel works. This article describes the system used at the Denain works of the *Société française de construction mécanique.* The requirements for such a system are: a method of rapid and exact testing, eliminating as far as possible the personal equation of the operator, and a convenient way of preserving the results so as to have them always ready for reference. After a considerable amount of experimenting it was found that Brinnel's test for hardness is the most simple and reliable, and that, together with a test made by breaking a test piece of standard dimensions by a rotary rammer, it was sufficient for determining the mechanical strength of the material. Three microscopic tests were also made of a section ground off, but not treated; and of metal treated with picric acid and picrate of soda. For each metal four series of tests were made: (*a*) metal in its natural state; (*b*) quenched in water once; (*c*) quenched in water twice; (*d*) quenched in water twice and tempered. The results of the tests are recorded on tablets on which are also placed samples of the metal showing the surface of fracture for each test and the imprint made by the balls in the hardness test, and micrographs from the microscopic tests. A collection of such tablets permits of making, rapidly and with certainty, a selection of the best material available for the given requirements. The article contains descriptions and drawings of some of the testing machines used by that concern.

Die Kühlung des Werkzeuges, N. N. Sawwin. *Dinglers Polytechnisches*

Journal, February 10, 17. 1912. 3 pp., 5 figs. *e.* (Cp. by the same author: ***Zeits. des Oesterr. Ingenieur u. Arch.-Vereines***, No. 32, 1911, ***Revue de Métallurgie***, February 1912, and ***Annals of the Polytechnic Institute of St. Petersburg***, Vol. 3, 1905.) When a steel shaft 300 mm (11.8 in.) thick and 2 m (6.5 ft.) long is turned in a lathe provided with a high-speed steel tool having a linear velocity of 12 m/min. (39 ft. per min.), and cuts a chip 80 qmm (0.1 sq. in.) in cross-section, the pressure at the cutting is 12,000 kg., the useful cutting work 2400 kgm. so that with a 75 per cent efficiency of the lathe the motor must develop over 42 h.p., and the total useful work for one passing of the tool (2 m or 6.5 ft.) is about 5,652,000 kgm (39,790,000 ft-lb.). Nearly all of this work is transformed into heat, and partly dissipated by radiation, partly transmitted to, and absorbed by, the lathe frame, while a large part of it goes to heat the shaving. F. W. Taylor[1] has first shown that the efficiency of a lathe may be increased (up to 40 per cent in cutting steel, and 16 per cent in cutting cast iron) by thoroughly *cooling the cutting tool by a water jet*, but cooling the tool is not all that a jet of liquid has to do. The long shaving of soft steel which stays on the piece for a considerable time exerts against it a strong friction, and that is what the use of the liquid must help to avoid. The exact loss of power due to this friction is as yet unknown, but the above quoted figures of Taylor show that it is very considerable; in the case of cast iron where the chips break off at once the increase of efficiency due to the use of a cooling (and lubricating) liquid was only 16 per cent, while in the case of steel with its long shavings the saving was as high as 40 per cent.

The *liquid used* must satisfy the following *mechanical conditions: (a)* it must efficiently cool the piece turned and cutting tool, and to do this must possess as high a heat conductivity and specific heat as possible; and (*b*) it must act as a good lubricant to take up the immense pressures between the piece turned and the chip, especially in the case of soft metal giving a long shaving. The first condition is best satisfied by water, the second by pure vegetable oil. There are also two *practical conditions: (a)* the liquid must be cheap, and (*b*) it must not attack the metal of the lathe. The author investigated the following liquids: linseed oil; an emulsion of water, oil, soap, and soda; soda solutions; and water. All these liquids were poured in a stream under equal pressure, from above, on to the cutting tool. The largest saving in power (30 per cent as compared with what was required when no lubrication was used) was obtained when linseed oil was used; machine oil came next; other cooling liquids did not appear to diminish the cutting friction to any considerable extent. Saturated soda solution gives the work a good surface, preserves the work and lathe from rusting, and is cheap, and hence makes a very good cooling medium.

It appears therefore that a *cooling and lubricating* agent ought to be used in *cutting steel* (e. g., linseed oil), but *only a cooling* agent in *working cast iron*, and the cheapest of all cooling materials, water, from Professor Sawwin's investigation. appears to be also the most efficient.

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[1] On the Art of Cutting Metals. 1906.

Procédé pour rendre l'aluminum inattaquable aux acides, aux alkalis et à tous autres agents extérieurs, M. Pucillo. *La Métallurgie*, February 7, 1912. 1/3 p. *d*. This rather complicated process may be applied to aluminum objects of any form, and consists in the following series of operations: (*a*) the aluminum object is first treated by an alkaline solution, then neutralized by acidulated water, and washed by pure water; (*b*) it is treated by chloride solutions which may be applied in the following order: iron chloride, zinc, tin, and ammonium chloride; (*c*) it is treated by an ammoniacal solution of copper chloride, to which is added some tartrate, such as sodium tartrate or calcium tartrate (5 per cent at least); (*d*) the object is then treated by an alcohol solution of zinc acetate, and neutralized by an aqueous solution of some carbonate, such as potassium carbonate; (*e*) finally it is treated by acidulated water, carefully washed in pure water, and heated to a temperature above 100 deg. cent. (212 deg. fahr.). At this stage the object is improved so far that it may be varnished or electrolytically covered by a metallic deposit. To make it perfectly acid-proof and temperature proof, the following must be done also: (*f*) the object is washed in a mixture of naphtha and drying oil, with some rosin added to it; before being used, this mixture is submitted to the action of oxygen, or of some strong oxidizing agent; (*g*) finally the object is completely dried while hot, and washed with hot caustic soda or another powerful alkaline agent. It is claimed that aluminum which has been so treated will resist practically every outside influence, can be painted by any paint or varnish and chemically cleaned again, etc.

Measurements

Messung hoher Umlaufzahlen mittels des Stroboskops, Joh. Schillo. *Elektrotechnische Zeits.*, February 15, 1912. *p*. Description of an optical method for measuring very high speeds of rotation. Ordinary tachometers cannot be applied when the speed of rotation exceeds 15,000 r.p.m., as is often the case with steam turbines, and the author recommends the stroboscopic method of measurement, introduced first by Benischke (cp. Electrical Review, London, January 5, 1900) and Wagner. The latter proposed the formula:

$$N.\ z = n.\ Z$$

where N is the number of revolutions per minute of the turbine, z the number of marks on the disc on the turbine-shaft, n the number of revolutions of the motor driving the stroboscop disc, and Z the number of slots on the stroboscop disc. This formula was sufficient as long as the speed of rotation to be measured could also be estimated from other data to a certain extent, but when the speed of rotation became extremely high, the formula ceased to be perfectly reliable, because, as Dr. Wagner himself has shown, a stationary image can be obtained whenever $N{:}n$ is equal to an integral number. Thus, when $z = 1$, $Z = 20$, and $n = 500$, a stationary image would be obtained when N is equal to 10,000, or 15,000, or 20,000, etc., and in that case there was no way to estimate, by inspection or from the amount of power used, whether the speed was 35,000 or 40,000 r.p.m. In order to make it possible to apply the method to the measurement of very high speeds, the author introduced the auxiliary process of counting the number of images appearing in the stroboscop.

Suppose a black disc with a white mark is placed on the shaft of a motor making 2100 r.p.m., and another disc with a slot in it is placed on the shaft of a motor making from 700 to 2100 r.p.m. (for stroboscopic disc see Fig. 8). If the slot on one disc and white mark on the other are at the beginning of the revolution in the position *I* just opposite each other, and both motors make 2100 r.p.m., they will be again opposite each other in position *II*, or, in other words, the white mark will be visible through the slot twice in each revolution. If the relation of speeds is 2:1, the mark will be seen three times in each revolution; if it is 3:1, one disc passes three parts of the path, while the other makes only one, and the mark will be visible after each quarter of a revolution. This permits

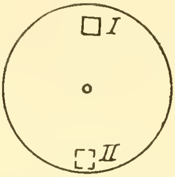


Fig. 8 Stroboscopic Disc

the deduction of the simple formula for the number of times the mark is visible through the slot in the stroboscop disc:

$$A = \frac{N}{n} + 1$$

for rotation in opposite direction and one slot in the disc

$$A = \frac{N}{n} - 1$$

for rotation in the same direction and one slot

$$A = s\left(\frac{N}{n} \pm 1\right)$$

for the case of *s* slots in the disc or *s* marks.

This shows that a stationary image may be obtained whenever $s\left(\frac{N}{n} \pm 1\right)$ in an integer. The author gives a table showing what formula for *A* has to be used for any number of slots and marks, but states that the smaller the number of slots and marks, the simpler the process of measurement and calculation is, the most convenient number both of slots and marks appearing to be 1. For a general description of stroboscops, besides the above quoted article, see Thompson, Light Visible and Invisible, p. 94-99. For a description of a stroboscopic fork and its application to the measurement of speed of rotation of electric machinery see Kennelly, Electrical World, December 26, 1908.

Exakte maal med konstant og progressiv tolerance, C. F. Helmboe. *Elektroteknisk Tidsskrift*, February 1912. 2 pp., 4 figs. *d.* Description of the *Johansson system of gages based on the principle of progressive tolerance*, or permissible deviation in a standard of measurement, which consists in making the combination gage within the tolerance determined for that size; this tolerance is further made to correspond with the sum of the tolerances of each of the single gages embodied in the combination gage in question. The coefficient of tolerance is taken as nearly as possible equal to the coefficient of expansion of steel, to avoid error in measurement due to the difference in temperature between the gage and the piece measured. For a general description of the Johansson Universal Combination Gaging Set see American Machinist, October 8, 1908.

Mechanics

EFFETS GYROSCOPIQUES, G. Clauzel. *Revue de mécanique*, January 31, 1912. 20 pp., 28 figs. *mtA*. The first of a series of articles, being a mathematical and analytical investigation of the so-called *gyroscopic phenomena*. The purpose of the author is to show how the couple of inertia forces in a gyroscope may be determined both as to its direction and as to its dimensions, and from that may be determined the position which the axis of rotation tends to occupy. He goes on to establish the general equations for a figure of revolution rotating about its axis, or a body free to rotate about a point on its supposedly fixed axis. The method applied by the author may be used for the determination of gyroscopic phenomena in the spinning top, the drifting of projectiles, and the rotation of turbines in a vessel or propellers in an airship.

BEITRAG ZUR BERECHNUNG DER SCHRAUBENFEDERN, H. Al. Siebeck. *Zeits. des Vereines deutscher Ingenieure*, December 30, 1911. 4 pp., 5 figs. *t*. A new method is given for determining a spring satisfying given conditions as follows: The efficiency of a spring depends on its greatest safe load and greatest steady deflection. The natural starting point for the computation of a helical spring is the extension diagram (Fig. 9) out of which can be obtained: (*a*) deflection of a single coil in mm.; (*b*) greatest safe load P_e in kg. which approaches more or less the greatest safe steady load in accordance with the variation in the number of deflections per unit time; (*c*) initial load P_v in kg. which may be equal to zero or even negative. P_e P_v represents therefore the actual useful load on the spring, and the coefficient of deflection of the spring h may be expressed as

$$h = \frac{H}{P_v - P_e} \dots\dots\dots\dots\dots\dots [1]$$

Therefore h is the compression or extension of one coil of the spring in mm. for change of useful load equal to 1 kg. Practice has shown the extreme importance of correct choice of the coefficient of deflection h, and it is advisable to give the deflection diagram of the springs on drawings of machinery where springs are used, to facilitate their test and installation at the shops.

The calculation of springs is considerably simplified by the introduction of a certain relation between the mean diameter of the coil D and the diameter of the spring wire d. Let this relation be $c = \frac{D}{d}$. The formula for the greatest safe load of the spring

$$P = \frac{\pi}{8} \frac{d^3}{D} K_d \dots\dots\dots\dots\dots\dots [2]$$

may then be written in the form

$$P = \frac{\pi}{8} K_d \frac{1}{c} d^2 \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

The author shows that by accepting the maximum intensity of stress in wire $K_d = 4070$ kg/qcm (57,835 lb. per sq. in.), he remains always within safe limits; at the same time this allows him to express the formula in the following form, convenient for slide rule calculations:

$$P = 1600 \frac{1}{c} d^2 \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

The coefficient of safety S_f of a spring is often determined in practice from

$$S_f = 1 + \frac{n_f}{150} \ldots\ldots\ldots\ldots\ldots\ldots [5]$$

where n_f is the number of double deflections per minute (or number per minute of deflections in one direction, i. e. number of compressions or expansions).

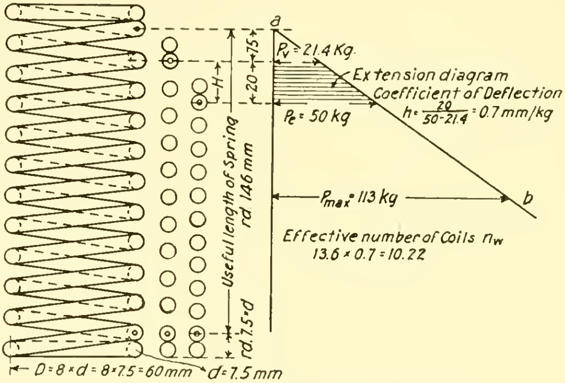

a
$P_v = 21.4$ Kg.
Extension diagram
Coefficient of Deflection
$h = \frac{20}{50-21.4} = 0.7$ mm/kg
$P_e = 50$ kg
75
20
H
Useful length of Spring rd 146 mm
$P_{max} = 113$ kg
b
Effective number of Coils n_w
$13.6 \times 0.7 = 10.22$
rd 7.5 = d
$D = 8 \times d = 8 \times 7.5 = 60$ mm
$d = 7.5$ mm

Fig. 9 Extension Diagram of Helical Spring

For the computation of Table 1 the author accepted certain standard values of $c = \frac{D}{d}$ as shown in the headline of the table, and $h = 1$.

The number of coils required for a spring corresponding to given conditions is obtained from the usual formula:

$$f = \frac{8 n_w D^3 P}{d^4 G} \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

where the transverse modulus of elasticity G is taken equal to 800,000 kg/qcm (11,400,000 lb. per sq. in.). By substituting in this formula h for $\frac{f}{P}$, and c for $\frac{D}{d}$, the author again obtains a formula for the number of coils in a spring in a form convenient for slide rule calculations:

$$n_w = \frac{10000}{c^3} dh \ldots\ldots\ldots\ldots\ldots\ldots [7]$$

The use of Table 2 can be illustrated by the following example. Required to find a spring for the exhaust valve of a four-cycle internal-combustion engine, 360 r.p.m. The number of double deflections per minute $n_t = 180$. According to equation [5], the coefficient of safety

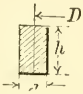
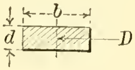
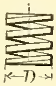
$$S_t = 1 + \frac{n_t}{150} = 1 + \frac{180}{150} = 2.2$$

The deflection diagram is drawn, as in Fig. 1, with a coefficient of deflection $h = 0.7$ mm/kg (0.0125 in. per lb.), in accordance with theoretically required accelerations and practical experience. For a valve lift of 20 mm. (0.78 in.) the load P_e is taken as 50 kg. (110 lb.), and that gives, with a coefficient of safety $S_t = 2.2$, the greatest safe load

$$P_{\max} = 2.2\ P_e = 2.2 \times 50 = 110 \text{ kg.} = 242 \text{ lb.}$$

Referring to the upper figures of Table 2, for values approaching that of $P_{\max}$ (they are underscored), it is seen that there are many such values, and that they lie practically along a diagonal line. The lower figures show the number of coils required with a coefficient of deflection unity, and since the coefficient of deflection was taken above as $h = 0.7$, the actual number of coils required may vary, according to the Table 2, from 0.7 × 85.8 to 0.7 × 0.265, the last figure being, of course, practically out of question. The diameter of the wire may vary from 5 mm. to 17 mm. (0.196 in. to 0.665 in.), and the values $d = 7.5$, $D = 60$ and $n_w = 0.7 \times 14.6 = 10.22$ will probably be chosen as most suitable.

TABLE 1 DIAMETER OF WIRE AND NUMBER OF COILS IN CYLINDRICAL AND CONICAL SPRINGS WITH RECTANGULAR CROSS-SECTION OF WIRE

	The Value of the Greatest Safe Load $P_{\max}$ of Table 1 must be multiplied by the Following Numbers c for Cylindrical and Conical Springs		The Number of Coils required n'_w with Coefficient of Deflection Unity of Table 1 must be multiplied by the Following Numbers c	
				
	h variable d constant	b variable d constant	For Cylindrical Springs	For Conical Springs
Reference Values of a	1	1	1	4
$a = 1$	1.13	1.13	1.41	5.66
$a = 1.25$	1.41	1.77	2.16	8.63
$a = 1.5$	1.70	2.55	2.94	11.75
$a = 1.75$	1.98	3.47	3.73	14.23
$a = 2$	2.26	4.53	4.53	18.11
$a = 2.5$	2.83	7.07	6.10	24.39
$a = 3$	3.40	10.19	7.64	30.56

The values in Table 2 are deduced for helical springs with circular cross-section. These values may be applied to springs with square or rectangular cross-section by multiplying them by values in Table 1 corresponding to the nearest value of *a*.

In Table 2 *d* is the diameter of the wire, *D* mean diameter of the coils, the upper figures indicate P_{max} = greatest safe steady load, the lower figures indicate n_w = number of coils required with coefficient of deflection unity.

Steam Engineering

NEUE PATENTE AUF DEM GEBEIT DER DAMPFKESSELFEUERUNG, Pradel. *Zeits. für Dampfkessel und Maschinenbetrieb.* February 2, 16 and 23, 1912. 7 pp., 28 figs. *d.* Brief accounts, with drawings, of new inventions relating to steam boiler firing, patented in Germany during the second half of 1911.

SCHÄDEN AN DAMPFKESSELN, G. Hilliger. *Zeits. für Dampfkessel und Maschinenbetrieb.* February 9, 1912. 2 pp., 4 figs. *cp.* In boilers having a wrought-iron shell and mild steel flues, the flues corroded very rapidly. This was at first ascribed to the use of unsatisfactory material in the flues, but the tests made by the International Association of Boiler Inspection Societies have shown that mild steel alone rusts no more than wrought iron, but that the corrosion is produced by electrolytic action between the two different kinds of materials: an electric potential of 65 millivolts was found between the shell and the material of one of the connecting pieces, this being also the spot most affected by corrosion. It is therefore very important for the life of a boiler to have it made, shell and flues, all of one material. The article also contains a discussion of the losses caused by defective boiler settings, for which see Electrical World, March 2, 1912.

APPAREILS DE MANUTENTION DES CENDRES DANS LES USINES DE L'OUEST-LUMIÈRE, À PUTEAUX (Seine). *Le Génie Civil.* February 3, 1912. 2 pp., 3 figs. *d.* Description of the installation for *handling ashes* at the above-named plant. The furnaces are underground, where the space available is limited, while the output of ashes is about 16 tons per hour. Bucket elevators were at first installed to bring the ashes and clinkers up to the street level direct from the furnace, i. e., hot, but the wear of the parts, due to the combined influence of heat and dust, was so great that this arrangement had to be given up, and electric elevators, partly automatic, partly semi-automatic, installed. These elevators work as follows: The ashes and clinkers are thrown on a grate having square holes, 0.08 m (0.3 in.) on each side, and clinkers larger than that are broken by hand-bars; from the grate the ashes are conveyed to a loading hopper, and from there to the cage of the elevator. The hopper is provided with a feeding trough oscillating about a horizontal axis; the cage of the elevator in coming down catches this trough and forces it to deliver the ashes into the cage, while a special arrangement prevents the overfilling of the cage. When full, the cage is taken up by an electric winch, and at a certain height is tripped over, and lets the ashes fall into a special reservoir, from which they are later on taken away. Everything works automatically, very little attendance is required, and the installation is said to have given entire satisfaction.

ASSOCIATION ALSACIENNE DES PROPRIÉTAIRES D'APPAREILS À VAPEUR, RAPPORT SUR LES TRAVAUX EXÉCUTÉS EN 1910, V. Kammerer. *Bulletin de la Société Industrielle de Mulhouse*, November 1911. 58 pp., numerous tables. *g. Yearly report of the Alsace Association of Owners of Steam Machinery* containing interesting *data on efficiency of various kinds of mechanical stokers, steaming capacity of boilers, steam consumption of steam engines and turbines of various makes, and heat consumption of gas engines.* Some of the general conclusions formed by the inspecting staff of the Association are of interest. A number of boilers were found to be almost entirely neglected and dirty, and they were located generally in narrow, dark and poorly installed boiler plants. Without going so far as to demand that a boiler plant should be spotless and painted white, there is no doubt that plenty of room, *light and cleanliness* are the very first things to be looked for, because they are not only indispensable for a good upkeep and safety of the plant, but may materially increase its efficiency and economy.

The association is distinctly against the use of *scale solvents* of which the composition is kept secret. Notwithstanding their high sounding names, they are generally made chiefly of soda, and some of them, especially those which contain chlorides, are not only useless, but may do harm. Scale must be dealt with on the basis of an analysis of the water, and not by introducing into the boiler some unknown composition.

After investigating several accidents it was found that it is generally dangerous to lay *steam-carrying pipes* above a certain length horizontally, and that they ought to be laid with considerable inclination towards the drain. It is also safer to make the bends and steam cocks in steel rather than in cast iron.

It is nearly impossible to estimate with any degree of precision the bending stresses to which are submitted *pipe flanges* when, in order to obtain a good joint, the bolts are screwed tightly, especially if the flange has to withstand at the same time stresses due to expansion. As a result, many of the joints in pipes and similar apparatus are working with very low factors of safety, as has been shown lately by the fact that accidents from piping have been far more numerous than from boilers, and with as fatal consequences.

STEHENDE GLEICHSTROM-SCHIEBERDAMPFMASCHINE MIT KURZEM ZYLINDER UND KURZEM KOLBEN, C. Sondermann. *Der praktische Maschinen-Konstrukteur*, February 1, 1912. 1 p., 2 figs. *d.* Description of a *straight-flow steam engine with slide-valve, short cylinder and short piston.* The machine can economically work non-condensing, and is said to give 16 to 20 per cent economy in fuel as compared with reciprocating steam engines with slide valves.

BEITRAGE ZUR BEURTEILUNG DES BETRIEBES VON DAMPFÜBERHITZERN, W. Zimmermann. *Der praktische Maschinen-Konstrukteur*, February 1, 1912. 2 pp., 1 data-sheet. *e.* Account and data of a test on the *efficiency of superheaters*, and conditions impairing it. The two causes found to be the

TABLE 2 DIAMETER OF WIRE AND NUMBER OF COILS IN HELICAL SPRINGS WITH CIRCULAR CROSS-SECTION OF WIRE

$\frac{d}{mm}$	$\frac{D}{d} = 4$	5	6	7	8	9	10	12	14	16	18	20	22.5	25	27.5	30	35	40
	4.0	3.2	2.67	2.29	2.00	1.78	1.60	1.33	1.14	1.00	0.889	0.800	0.711	0.640	0.582	0.533	0.457	0.400
1.0	15.6	8.0	4.63	2.92	1.95	1.37	1.00	0.579	0.364	0.244	0.172	0.125	0.088	0.064	0.048	0.037	0.023	0.016
	9.0	7.2	6.00	5.14	4.50	4.00	3.60	3.00	2.57	2.25	2.00	1.80	1.60	1.44	1.31	1.20	1.03	0.900
1.5	23.4	12.0	6.95	4.37	2.93	2.06	1.50	0.869	0.546	0.366	0.257	0.188	0.132	0.096	0.072	0.056	0.035	0.023
	16.0	12.8	10.7	9.14	8.00	7.11	6.40	5.33	4.57	4.00	3.56	3.20	2.84	2.56	2.33	2.13	1.83	1.60
2.0	31.2	16.0	9.26	5.83	3.90	2.74	2.00	1.16	0.728	0.488	0.343	0.250	0.176	0.128	0.096	0.074	0.047	0.031
	25.0	20.0	16.7	14.3	12.5	11.1	10.0	8.33	7.14	6.25	5.56	5.00	4.44	4.00	3.64	3.33	2.86	2.50
2.5	39.0	20.0	11.6	7.29	4.88	3.43	2.50	1.45	0.910	0.610	0.429	0.313	0.220	0.160	0.120	0.093	0.058	0.039
	36.0	28.8	24.0	20.6	18.0	16.0	14.4	12.0	10.3	9.00	8.00	7.20	6.40	5.76	5.24	4.80	4.11	3.60
3.0	46.8	24.0	13.9	8.75	5.85	4.11	3.00	1.74	1.09	0.732	0.515	0.375	0.263	0.192	0.144	0.111	0.070	0.047
	49.0	39.2	32.7	28.0	24.5	21.8	19.6	16.3	14.0	12.3	10.9	9.80	8.71	7.84	7.13	6.53	5.60	4.90
3.5	54.6	28.0	16.2	10.2	6.83	4.80	3.50	2.03	1.27	0.854	0.600	0.438	0.307	0.224	0.168	0.130	0.082	0.055
	64.0	51.2	42.7	36.6	32.0	28.4	25.6	21.3	18.3	16.0	14.2	12.8	11.4	10.2	9.31	8.53	7.31	6.40
4.0	62.4	32.0	18.5	11.7	7.80	5.48	4.00	2.32	1.46	0.976	0.686	0.500	0.351	0.256	0.192	0.148	0.093	0.062
	81.0	64.8	54.0	46.3	40.5	36.0	32.4	27.0	23.1	20.3	18.0	16.2	14.4	13.0	11.8	10.8	9.26	8.10
4.5	70.2	36.0	20.8	13.1	8.78	6.17	4.50	2.60	1.64	1.10	0.772	0.563	0.395	0.288	0.216	0.167	0.105	0.070
	100	80.0	66.7	57.1	50.0	44.4	40.0	33.3	28.6	25.0	22.2	20.0	17.8	16.0	14.5	13.3	11.4	10.0
5.0	78.0	40.0	23.2	14.6	9.75	6.85	5.00	2.90	1.82	1.22	0.858	0.625	0.439	0.320	0.240	0.185	0.117	0.078
	121	96.8	80.7	69.1	60.5	53.8	48.4	40.3	34.6	30.3	26.9	24.2	21.5	19.4	17.6	16.1	13.8	12.1
5.5	85.8	44.0	25.5	16.0	10.7	7.54	5.50	3.18	2.00	1.34	0.943	0.688	0.473	0.352	0.265	0.204	0.128	0.086
	144	115	96.0	82.3	72.0	64.0	57.6	48.0	41.1	36.0	32.0	28.8	25.6	23.0	20.9	19.2	16.5	14.4
6.0	93.6	48.0	27.8	17.5	11.7	8.22	6.00	3.47	2.18	1.46	1.03	0.750	0.527	0.384	0.289	0.222	0.140	0.094
	169	135	113	96.6	84.5	75.1	67.6	56.3	48.3	42.3	37.6	33.8	30.0	27.0	24.6	22.5	19.3	16.9
6.5	101	52.0	30.1	18.9	12.7	8.91	6.50	3.76	2.37	1.59	1.11	0.813	0.571	0.416	0.313	0.241	0.151	0.101
	196	157	131	112	98.0	87.1	78.4	65.3	56.0	49.0	43.6	39.2	34.8	31.4	28.5	26.1	22.4	19.6
7.0	109	56.0	32.4	20.4	13.7	9.59	7.00	4.05	2.55	1.71	1.20	0.875	0.615	0.448	0.337	0.259	0.163	0.109
	225	180	150	129	113	100	90.0	75.0	64.3	56.3	50.0	45.0	40.0	36.0	32.7	30.0	25.7	22.5
7.5	117	60.0	34.7	21.9	14.6	10.3	7.50	4.34	2.73	1.83	1.29	0.938	0.659	0.480	0.361	0.278	0.175	0.117
	256	205	171	146	128	114	102	85.3	73.1	64.0	56.9	51.2	45.5	41.0	37.2	34.1	29.3	25.6
8.0	125	64.0	37.0	23.3	15.6	11.0	8.00	4.63	2.91	1.95	1.37	1.00	0.702	0.512	0.385	0.296	0.186	0.125
	289	231	193	165	145	128	116	96.3	82.6	72.3	64.2	57.8	51.4	46.2	42.0	38.5	33.0	28.9
8.5	133	68.0	39.4	24.8	16.6	11.6	8.50	4.92	3.09	2.07	1.46	1.06	0.746	0.544	0.409	0.315	0.198	0.133

	324	259	216	185	162	144	130	108	92.6	81.0	72.0	64.8	57.6	51.8	47.1	43.2	37.0	32.4
9.0	140	72.0	41.7	26.2	17.6	12.3	9.00	5.21	3.28	2.20	1.54	1.13	0.790	0.576	0.433	0.333	0.210	0.140
	361	289	241	206	181	160	144	120	103	90.3	80.2	72.2	64.2	57.8	52.5	48.1	41.3	36.1
9.5	148	76.0	44.0	27.7	18.5	13.0	9.50	5.50	3.46	2.32	1.63	1.19	0.834	0.608	0.457	0.352	0.221	0.148
	400	320	267	229	200	178	160	133	114	100	88.9	80.0	71.1	64.0	58.2	53.3	45.7	40.0
10	156	80.0	46.3	29.2	19.5	13.7	10.0	5.79	3.64	2.44	1.72	1.25	0.878	0.640	0.481	0.370	0.233	0.156
	484	387	323	277	242	215	194	161	138	121	108	96.8	86.0	77.4	70.4	64.5	55.3	48.4
11	172	88.0	50.9	32.1	21.5	15.1	11.0	6.37	4.00	2.68	1.89	1.38	0.966	0.704	0.529	0.407	0.256	0.172
	576	461	384	329	288	256	230	192	165	144	128	115	102	92.2	83.8	76.8	65.8	57.6
12	187	96.0	55.6	35.0	23.4	16.4	12.0	6.95	4.37	2.93	2.06	1.50	1.05	0.768	0.577	0.444	0.280	0.187
	676	541	451	386	338	300	270	225	193	169	150	135	120	108	98.3	90.1	77.3	67.6
13	203	104	60.2	37.9	25.4	17.8	13.0	7.53	4.73	3.17	2.23	1.63	1.114	0.832	0.625	0.481	0.303	0.203
	784	627	523	448	392	348	314	261	224	196	174	157	139	125	114	105	89.6	78.4
14	218	112	64.8	40.8	27.3	19.2	14.0	8.11	5.10	3.42	2.40	1.75	1.23	0.896	0.673	0.518	0.326	0.218
	900	720	600	514	450	400	360	300	257	225	200	180	160	144	131	120	103	90.0
15	234	120	69.5	43.7	29.3	20.6	15.0	8.69	5.46	3.66	2.57	1.88	1.32	0.960	0.722	0.555	0.350	0.234
	1020	819	683	585	512	455	410	341	293	256	228	205	182	164	149	137	117	102
16	250	128	74.1	46.6	31.2	21.9	16.0	9.26	5.82	3.90	2.74	2.00	1.40	1.02	0.770	0.592	0.373	0.250
	1160	925	771	661	578	514	462	385	330	289	257	231	206	185	168	154	132	116
17	265	136	78.7	49.6	33.2	23.3	17.0	9.84	6.19	4.15	2.92	2.13	1.49	1.09	0.818	0.629	0.396	0.265
	1300	1040	864	741	648	576	518	432	370	324	288	259	230	207	189	173	148	130
18	281	144	83.3	52.5	35.1	24.7	18.0	10.4	6.55	4.39	3.09	2.25	1.58	1.15	0.866	0.666	0.419	0.281
	1440	1160	963	825	722	642	578	481	413	361	321	289	257	231	210	193	165	144
19	296	152	88.0	55.4	37.1	26.0	19.0	11.0	6.92	4.64	3.26	2.38	1.67	1.22	0.914	0.703	0.443	0.296
	1600	1280	1070	914	800	711	640	533	457	400	356	320	284	256	233	213	183	160
20	312	160	92.6	58.3	39.0	27.4	20.0	11.6	7.28	4.88	3.43	2.50	1.76	1.28	0.962	0.740	0.466	0.312
	1760	1410	1180	1010	882	784	706	588	504	441	392	353	314	282	257	235	202	176
21	328	168	97.2	61.2	41.0	28.8	21.0	12.2	7.64	5.12	3.60	2.63	1.84	1.34	1.01	0.777	0.489	0.328
	1940	1550	1290	1110	968	860	774	645	553	484	430	387	344	310	282	258	221	194
22	343	176	102	64.1	42.9	30.1	22.0	12.7	8.01	5.37	3.77	2.75	1.93	1.41	1.06	0.814	0.513	0.343
	2120	1690	1410	1210	1060	940	846	705	605	529	470	423	376	339	308	282	242	212
23	359	184	107	67.0	44.9	31.5	23.0	13.3	8.37	5.61	3.94	2.88	2.02	1.47	1.11	0.851	0.536	0.359
	2300	1840	1540	1320	1150	1020	922	768	658	576	512	461	410	369	335	307	263	230
24	374	192	111	70.0	46.8	32.9	24.0	13.9	8.74	5.86	4.12	3.00	2.11	1.54	1.15	0.888	0.559	0.374
	2500	2000	1670	1430	1250	1110	1000	833	714	625	556	500	444	400	364	333	286	250
25	390	200	116	72.9	48.8	34.3	25.0	14.5	9.10	6.10	4.29	3.13	2.20	1.60	1.20	0.925	0.583	0.390

most prejudicious to a good working of a superheater were state of impurity of the surface of the superheater tubes and cracks in the superheater brickwork.

EINIGE DAMPFKRAFTANLAGEN MIT ABWÄRMEVERWERTUNG, Max Hottinger. *Zeits. des Vereines deutscher Ingenieure*, January 6, 13 and 20, 1912. 24 pp., 39 figs. *dp.* A series of articles describing the modern German and Swiss *practice in steam power installations with utilization of exhaust steam.* Fig 10 shows a boiler and power plant where exhaust steam is not utilized. From the boilers K the steam flows on one side to the high and low-pressure cylinders H and N of the engine, and from there, through an oil-separator O, to the surface or jet condenser K_o, from which the water of condensation flows to the tank R. From the other side of the boiler live steam flows into the heating system Hz, which may of course be replaced by water preheaters, etc. Before reaching the heating system, the steam passes through the stop-valve Ab, steam pressure reducing valve Rv, and safety valve Sv, the water of condensation being conveyed also into the tank R. From there the water passes through the auxiliary tank Wr, where as much fresh water is added as is necessary, and is driven by the pump P, through the economizer E, back into the boiler K. Fig. 11 shows the same plant with the difference that it now uses for heating purposes exhaust steam to which low-pressure live steam is added only when the demand for heating exceeds the amount of steam available from the superheat. There is a good oil-separator installed between the receiver and the heating system because oil in heating tubes injures their heat conductivity. No oil-separator is used with steam turbines because their steam is free from oil.

The demand for power may be steady, and that for heat variable, or the reverse, or both may be variable, which necessitates a reliable regulation of the distribution of exhaust steam. The most convenient basis for regulation proved to be the pressure in the exhaust steam main. When the heating system suddenly calls for less steam, or the steam engine wants more to take care of a sudden increase of load, the pressure in the exhaust steam main immediately increases, and this increase of pressure is transferred to the governor y (Fig. 12), which automatically increases the admission of steam to the low-pressure cylinder, thus bringing down to the normal level the pressure in the exhaust steam main. With the transfer of part of the load to the low-pressure cylinder the governor z maintains the speed of the engine the same as before.

A well designed governor y thus becomes the cardinal point of the whole system. The article describes several types which have been built by Sulzer Brothers in Winterthur, Switzerland, and abandoned after trial. The following is the type now in use: A mercury regulator (Fig. 12) in which the steam pressure displaces the mercury, causes rising and sinking of a cast-iron piston k in the mercury, weighted with a lead attachment. The piston k is connected by lever a and rod b with the admission valve c of the low pressure cylinder, and by rising and sinking in the mercury bath regulates the admission to that cylinder. Any desired pressure in the exhaust steam main, within certain limits, may be obtained by the movable weight *g*. The steam presses on the mercury and drives it, through the opening *e*, into the pipe *r*, thus changing the degree of immersion of the piston *k*. The device *f* allows to vary the area of the opening *e*, and thus change the resistance offered by it to the passage of the mercury, the purpose of this small opening being to dampen the accidental variations of pressure in the exhaust steam main.

The article contains description of some installations particularly noteworthy for their economic working and full utilization of exhaust steam, and data of tests showing the comparative economy obtained from utilizing exhaust steam. It was found that exhaust steam may best be utilized in such plants as breweries, where there is a constant and comparatively regular demand for heat for heating water and for manufacture.

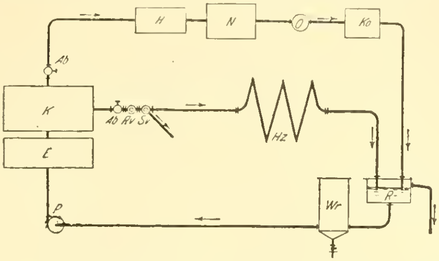


Fig. 10 Plant without Utilization of Exhaust Steam

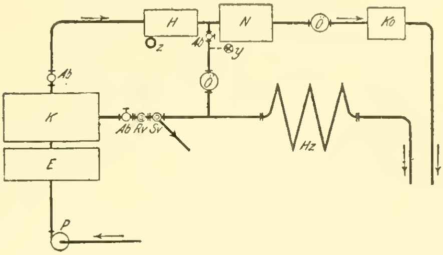


Fig. 11 Same Plant with Utilization of Exhaust Steam

Strength of Materials and Materials of Construction

Griffes à serrage automatique pour la manutention des tôles. *La Métallurgie*, February 7, 1912. 1/3 pp., 2 figs. *d.* Neither hemp ropes nor chains can be conveniently used *for handling sheet-iron plates*, because ropes are easily cut through, and the plates can slip out of the chains. The article describes a convenient and safe *automatic grip* invented for this purpose by Rudolf. It has the form of an ordinary pinch-bar provided with a toothed clamp eccentrically pivoted on one of the jaws of the bar. The iron plate is inserted between the fixed jaw of the bar and the movable clamp and by its weight draws the clamp down until a strong grip is exerted, which makes it practically impossible for the plate to slip out.

Essais sur l'usure des bronzes, Portevin and Nusbaumer. *Revue de métallurgie*, February 1912. 16 pp., 19 figs. *c.* Data and results of tests on the *wearing qualities of various bronzes* rubbing against well lubricated smooth steel. It was found that the wear of ordinary bronzes was proportional to the content of tin; the introduction of phosphorus produces a bronze with better wearing qualities than non-phosphorus bronze with high content of tin, but wearing more than non-phosphorus bronze with low content of tin; the tendency to crystallize by heating is met with in bronze as well as in steel, such crystallization facilitating plastic deformation of the bronze. The article is to be continued.

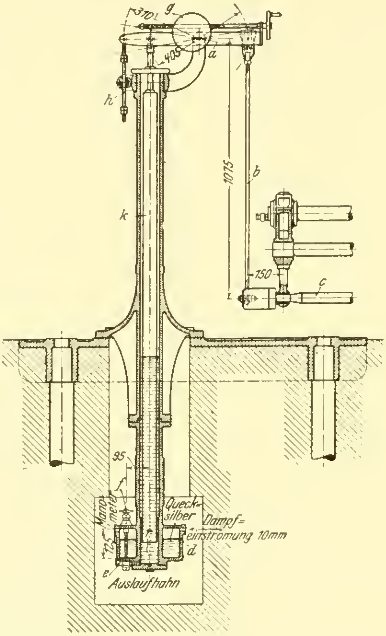


Fig. 12 Mercury Regulator for Pressure in Exhaust Steam Main

Versuche mit umschnürtem Gusseisen, System Dr. v. Emperger. *Beton und Eisen*, February 2, 1912. 3 pp., 21 figs. *c.* Data from tests of "*strapped*" *cast iron.* Neither cast iron nor concrete columns are used much in construction now, the first on account of its brittleness and low resistivity to fire, and the second for the reason that a very slight mistake in construction may lead to the column being weak, and to its breaking down, often with fatal results to the whole structure. Dr. v. Emperger claims to have produced an important new material of construction, which consists in covering a cast-iron column by a concrete jacket strapped all around by a wire helix. In tests which were made by the Austrian Bureau of Reinforced Concrete Construction the cast-iron column broke under a pressure of 137 tons, or 3420 kg/qcm (say 48000 lb. per sq. in.), while a column of the same size with an external concrete jacket, of 497 qcm (77 sq. in.) total area, broke only under a pressure of 315 tons. The cast-iron reinforcing member may be either a solid column or a tube.

VERLADEBRÜCKE FÜR HOLZ. *Dinglers Polytechnisches Journal*, February 17, 1912. 1½ pp., 2 figs. *d.* Describes a *platform for loading timber into cars.* The traveling motor hoist is a single rail trolley running along an I-shaped rail. The power from the lifting motor to the cable drum is transmitted by a worm gear and two toothed wheels. Besides the load pressure brake in which the braking action is proportional to the load, an electromagnetic brake is installed, the main duty of which is to stop the rotating masses after the motor is switched off, and thus to bring the vertical and side motion of the crane-hooks absolutely under control of the operator. The motors are driven by direct current at 440 volts.

TABELLE ZUR BESTIMMUNG DER SPANNUNGEN IN EISENBETONPLATTEN, E. Suenson. *Beton und Eisen*, February 2, 1912. 1 p. *p.* A table for the determination of *stresses in reinforced concrete slabs.* The author gives a formula which permits, by the use of the table, of finding the stresses both in the iron and the concrete, easily and rapidly. The formulae are convenient for slide-rule calculation.

BALKENVERSUCHE, Dr. F. v. Emperger. *Beton und Eisen*, February 2. 1912. 1½ pp., 3 figs. *t.* The author shows that as yet we know comparatively little as to the *strength of concrete beams* and other structural parts, and attempts to establish a general plan for tests on concrete, and in particular, reinforced concrete beams.

ÜBER DEN EINFLUSS VON ANSTRICHEN AUF DAS ROSTEN DES EISENS, Erik Liebreich and Fritz Spitzer. *Zeits. für Elektrochemie*, February 1, 1912. 5 pp., 8 figs. *c.* The author shows the *fallacy* of the commonly accepted view *that several coats of paint protect iron from rusting better than one.* His experiments with many kinds of paints have uniformly shown that when iron with one coat of paint was as yet practically unaffected by rusting, iron with two coats of paint was partly rusted, with three coats, more so, and with four coats of paint entirely covered by rust. The experiments do not yet permit of offering a well supported explanation of this phenomenon, but the author thinks that the application of several coats of paint, by increasing the number of contacts between the iron and the paint, increases also the number of local electric elements formed at the surface of iron, thus causing large variations in electric potential along the surface, and giving rise to stronger currents than in the case of a single coat of paint. (Cp. Engineering, February 16, 1912, p. 222.)

Testing

UN PROGRAMME D'ESSAIS, M. d'About. *La Technique automobile et aérienne*, February 15, 1912. 3½ pp. *t.* In 1901 The American Society of Mechanical Engineers proposed a *program for testing gas engines.* R. E. Mathot and Ch. de Herbais de Thun, at the Congress at the Liège exhibition, criticized it on the ground that under industrial conditions not all the tests and measurements recommended by that program can be actually performed. The author of the present article aims to establish a program mainly for the testing of automobile and aeronautical motors, i. e., small two and four-cycle motors having as a rule a high angular velocity. This velocity makes it practically impossible to use indicator diagrams, and the motors must be compared on the basis of effective, and not indicated, power. A complete test, according to the author, must consist of the following operations: (*a*) verification of the organic elements of the machine; (*b*) verification and calibration of the apparatus used; (*c*) measurement of the maximum effective power; (*c*) measurement of the angular velocity corresponding to the maximum effective power; (*d*) measurement of temperatures; (*e*) measurement of consumption. These measurements are in most cases sufficient to determine the quality of a motor, but are not full enough to permit of any general deductions, and without such deductions there can be no progress. The following must therefore be added: (*f*) measurement of power at various speeds of the motor; (*g*) measurement of temperatures for these speeds; (*h*) measurement of consumption of fuel for these speeds; (*i*) determination of the speed requiring minimum consumption of fuel; (*j*) measurement of losses due to friction, with and without compression.

All the results have to be recorded specifically, i. e., on the basis of either a liter of volume of cylinder swept by the piston per revolution, or of a liter of volume of cylinder swept by the piston per minute, or horsepower-hour, or caloric unit of fuel, as the case may be. The measurement of power at various speeds permits the construction of the power curve or characteristic of the motor; the measurement of temperatures and consumption of fuel at various speeds with the last item expressed in specific units of consumption per horsepower-hour and per liter of volume of cylinder swept by the piston gives sufficient data for the construction of a curve of efficiency of the motor; finally, the data on losses by friction, with and without compression, show the mechanical efficiency of the motor and the efficiency of its valve gear. It certainly takes a long time to make all these measurements, but they are neither delicate nor expensive. The article also contains detailed directions for making the measurements required by this program.

Thermodynamics

ÜBER DIE SPEZIFISCHE WÄRME DER GASE, Niels Bjerrum. *Zeits. für Elektrochemie.* 3 pp., 1 fig. *t.* This article is a short exposition of a longer work which is promised to appear in the Zeits. für physikalische Chemie, and in which the author proposes, among other things, to show that the *molecular heat of steam* rises with the temperature more than would be expected in accordance with the quanta equation.

Miscellaneous

LES ESCALIERS HOCQUART, A. S. Wadou. *Electro,* January 1912. 4 pp., 7 figs. *d.* Description of the *Hocquart passenger conveyors* for automatically conveying passengers from one floor to another.

WERT DES WASSERS FÜR KRAFTERZEUGUNG UND FÜR BEWASSERUNG, E.

Krüger. *Zeitschrift des Bayerischen Revisionsvereins*, No. 21, XV Jahrg. *g.* The author shows by a comparative calculation that, *economically, water used for irrigation purposes gives* 10 *to* 55 *times better results than that used for power*, on the supposition that the power installations are large and well laid, which is not always the case, and that irrigated land is used for agricultural purposes. The advantage in favor of irrigated land becomes, however, still more marked when the land is used for higher cultures, production of table vegetables, gardening, etc.

Deutsche Motorpflüge, K. Praetorius. *Zeits. des Mitteleuropäischen Motorwagen-Vereins*, No. 2, 1912. 3 pp., 7 figs. *d.* Describes a *German motor-plow*, invented by Koszoegi, and manufactured by Lanz in Mannheim. It is of the "milling" type, and has a driving shaft with the cutters arranged tangentially to the circle of rotation of the shaft, and working like milling cutters; the cutters not only break the earth, but also push the whole machine forward. This arrangement has the advantage of permitting the machine being built as heavy, and therefore as strong, as desired, and the use of thick cylinder walls and very substantially built machine parts.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(XVI)

ARTICLES IN PERIODICALS[1]

Asphyxies par les gaz des hauts-fourneaux, les, Ad. Breyre. *Annales des Mines de Belgique*, January 1912. 100 pp., 50 figs., 2 tables. *A*.

Asphyxiation caused by the gases from blast furnaces, gas producers, etc. Annual report of accidents, etc., and their causes. Article shows some excellent layouts of gas producer plants, the uses of blast furnace gases to heat boilers, etc.

Diesel Engine to the Larger Sea-Going Vessels, The Application of the, W. Kaemmerer. *Zeitschrift des Vereines deutscher Ingenieure*, January 20, 1912. *chp*.

Diesel Engined Oil Barge Built, First American. *International Marine Engineering*, March 1912. 5½ pp., 6 figs.

Account of the 200-ft. steel barge built for the Standard Oil Co.

Diesel Marine Engine, 100-Shaft-Horse-Power Reversible. *Engineering*, February 16, 1912. 2 pp., 8 figs.

Diesel Motor Ship Selandia, Axel Holm. *International Marine Engineering*, March 1912. ¾ p., 1 fig.

Describes vessel and engine.

Dieselmotoren, Thermodynamische Untersuchung schnellaufender, Otto Köhler. *Zeitschrift des Vereines deutscher Ingenieure*, February 10, 1912. 2½ pp., 7 curves. *m*.

Thermodynamic investigation of high-speed Diesel engines.

Diesel und Explosionsmaschinen Benzischer Bauart. *Der praktischer Maschinen Konstructeur*, January 4, 1912. 2 pp., 11 figs. *d*.

Diesel and combustion engines built by Benz. Describes some modern suction gas engines and the Benz crude oil motor. A two-page separate sheet gives very good information about the detail designs of the Benz crude oil motor. See also Foreign Review.

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[1] Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *h* historical; *m* mathematical; *p* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

Gas-Driven Cargo Vessel, Sea-Going. *The Engineer* (London), February 16, 1912. 2½ pp., 5 figs. *dpA*.

This vessel is 120 ft. long, has a carrying capacity of 350 tons and is equipped with 180-h.p. 6-cylinder vertical gas engines, two 100-h.p. gas producers and necessary auxiliaries. Has been in service for six years, giving 1 i.h.p. per hr. on ¾ lb. bituminous coal.

Gaserzeugerbetrieb, Die Gewinnung der Nebenerzeugnisse beim, Anton Gwiggner. *Stahl und Eisen*, December 21, 1911, and February 1, 1912. *p*.

Article on the recovery of by-products from the operation of gas generators.

Gas Generator Plant, Tests of, K. Neumann. *Zeitschrift des Vereines deutscher Ingenieure*, February 17, 1912. 1½ pp.

Discussion on the above article appearing in *Zeitschrift des Vereines deutscher Ingenieure*, 1911, page 892, by Withol and the author.

Kraftgasgeneratoren Anlage für Feinkohle, H. L. *Braunkohle*, January 12, 1912. 2 pp., 1 fig. *dC*.

Gas producer fed by coal dust. Grate arrangement similar to Roney stoker, allowing comparatively easy passage of the air through the coal dust. See also Foreign Review, March 1912.

Luftgasheizung in der Hauptwerkstatt Delitzsch, Die, E. Krause. *Glasers Annalen*, February 1, 1912. 10 pp., 2 figs., 19 tables, 1 curve.

Air-gas heating of the machine shops at Delitzsch.

Marine Gas Engines; Their Design and Application, E. N. Percy. *International Marine Engineering*, February 1912. 3 pp.

Motors for Lifeboats. *The Engineer* (London), March 1, 1912. 2 pp., 8 figs. 1 table. *dpA*.

Description and particulars of motor-driven lifeboats now in service: the Fay and Brown, Taylor, Thornycroft, Blake and Wolseley engines; with Gaine's, Villinger's and Meissner's reversible propeller; also the Hesse and Savory reverse gear and others.

Oil Engine, The Rumely. *International Marine Engineering*, March 2, 1912. 2 pp., 2 figs.

Describes the Rumely marine oil engine, 6 cylinder, 125 h.p. rated.

Oil Engine, The Two-Cycle Single-Acting Nuremberg Marine. *Engineering*, February 9, 1912. 3⅓ pp., 8 figs.

Describes a 6-cylinder, 150-b.h.p. engine.

Producer, The Mathot Suction. *Power*, February 27, 1912. 1⅓ pp., 1 fig., 1 table.

A producer which permits of the burning of low-grade fuel of the smallest size. The gas in passing from the top of the producer to a bottom outlet superheats the steam given off by the water vaporizer before reaching the fuel bed, allowing a greater quantity of steam to be dissociated without cooling the gas.

Rohoelmotoren, Neuere, Ch. Pohlmann. *Dinglers Polytechnisches Journal*, February 17 and 24, 1912. 10 pp., 16 figs., 1 table.

New type of crude oil motors. See also Foreign Review, March 1912.

Staubbestimmung im Gichtgas, Ueber, O. Johannsen. *Stahl und Eisen*, January 4, 1912. 4 pp., 4 figs. *p*.

Article on the determination of dust in blast furnace gases.

Turbine, A 1000-H.P. Gas. *Engineering News*, February 1, 1912. ¾ p.

General description of internal-combustion turbine built by Brown, Boveri & Co., Mannheim, Germany.

REPORTS OF MEETINGS

ST. LOUIS MEETINGS, MARCH 6 AND 20

The Society coöperated in a meeting conducted by the St. Louis association of members of the American Society of Civil Engineers, held in the Engineers Club on March 6, when The Use of Water Meters was presented by E. E. Wall, assistant water commissioner of St. Louis, and discussed by Edward Flad, Mem.Am.Soc.M.E., consulting engineer, S. Bent Russell, secretary of the Parker-Russell Mining & Manufacturing Company, of St. Louis, Hiram Phillips, consulting engineer, J. R. Cullinane, and others.

On March 20 the Engineers Club conducted a meeting in which the members of the Society participated, Concrete Construction of the East River Wall and Circulating Water Intake at the Ashley Street Station being presented by R. H. Nicholson, construction engineer with the Union Electric Light & Power Company, St. Louis.

PHILADELPHIA MEETING, MARCH 7

A meeting of the Society was held in Philadelphia on March 7th, the American Institute of Electrical Engineers and the Electrical Section of the Franklin Institute coöperating. A paper on The Electrification of Main Line Railways was presented by Mr. William J. Clark of New York.

Mr. Clark spoke of the accomplishments of electric traction and the bearing of these on the subject presented, and said that it was difficult to determine just what a main line railroad was. Former steam railroads now electrified are less entitled to qualify as main line roads than many of the so-called electric railways. The paramount reason for electrification will probably be, in the future, the advantageous moving of freight. The total tonnage now hauled by the electric locomotives in operation amounts to over one-third of the entire freight tonnage on the steam roads, although the length of haul is short. In many instances the total cost per ton mile approximates one cent. A distinctive type of the electric main line road is that for towage on canals, the most extensive example of which is the Panama Canal line for towing vessels through the locks. Accuracy and reliability of control secured by these cannot be obtained by mechanical means. There have been great changes in the character of the so-called street railways since 1890, in that these have invaded and expanded the transportation field of main line railways. Making capital investment for electrification has been found cheaper than reducing gradients for steam operation, and cheaper current has been obtained by consolidation of electric railways with power companies. Remarkable results of increased earnings from electrification have been attained on the Manhattan System, and on the Elevated Roads in Chicago, etc. Most of the steam roads now electrified have shown highly satisfactory results.

More electrification has not been accomplished probably because of the difficulty in raising capital and on account of the battle of the systems among electrical engineers. In Europe and Canada where these conditions do not exist much greater progress has been made. The service is one of great public benefit and it is to be regretted that more rapid progress has not been made.

NEW YORK MEETING, MARCH 12

A paper on Practical Problems in Tap and Screw Making by Frank O. Wells, president and treasurer of the Wells Brothers Company, Greenfield, Mass., was presented to H. E. Harris, testing engineer of the company, at a meeting of the Society in New York on March 12. The paper dealt with the importance of size and lead in the cost of assembling manufactured work, as well as the practical limits of accuracy, the reasons for abandoning the V-thread, the proper size of tap drills, the power required for tapping, the effect of lubricants on size and power, and other interesting points.

Among those who discussed the paper were F. G. Coburn; W. R. Porter, Assoc. Am.Soc.M.E., assistant master mechanic of the S. S. White Dental Manufacturing Company, Princes Bay, Staten Island; A. A. Fuller; George W. Adams; Howard Reed; G. A. Gaulison; Horace K. Jones, Mem.Am.Soc.M.E., mechanical superintendent, Corbin Screw Corporation, New Britain, Conn.; Charles B. Russell; J. E. Winter; George B. Pickop, Mem.Am.Soc.M.E., Universal Screw Company, Hartford, Conn.; J. M. Carpenter, Mem.Am.Soc.M.E., president of J. M. Carpenter Tap & Die Company, Pawtucket, R. I.; and written discussions were read from C. B. Buxton, tool supervisor, American Locomotive Company, Providence, R. I.; Wilfred Lewis, Mem.Am.Soc.M.E., president Tabor Manufacturing Company, Philadelphia, Pa.; Luther D. Burlingame, Mem.Am.Soc. M.E., chief draftsman, Brown & Sharpe Company, Providence, R. I.; George W. Adams, Eastman Kodak Company, Rochester, N. Y.

BOSTON MEETING, MARCH 16

At a meeting of the Society in Boston on March 16 a paper, Results of Tests on the Discharge Capacity of Safety Valves, was presented by the author, E. F. Miller, Mem.Am.Soc.M.E., professor of steam engineering of the Massachusetts Institute of Technology, together with an addition to the paper by A. B. Carhart, Mem.Am.Soc.M.E., superintendent of the Crosby Steam Gage & Valve Company of Boston. Charles H. Chase, Mem.Am.Soc.M.E., professor of steam engineering at Tufts College, presented some comparisons of other published tests, and F. H. Keyes, Mem.Am.Soc.M.E., a consulting engineer of Boston, also participated in the discussion.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

On March 6, the Armour Institute of Technology Student Branch was addressed by Sydney V. James, on Scientific Aeroplane Model Testing. The development of the Aeroplane model for experimental purposes was outlined, with examples showing what close approximations have been made to actual flying conditions by this method in the past. A. J. Beerbaum, R. Redlich, A. W. Semerak, J. A. McCague, I. Newman and L. H. Philleo took part in the discussion which followed.

COLUMBIA UNIVERSITY

A paper on The Field for the Mechanical Engineer in Locomotive Manufacture, by L. L. Park, was presented at the February 23 meeting of the Columbia University Student Branch. This was followed by a short talk by Dr. Charles E. Lucke, Mem.Am.Soc.M.E., on the Adaptability of Mechanical Engineering to Non-Mechanical Industries.

CORNELL UNIVERSITY

Wm. T. Magruder, Mem.Am.Soc.M.E., read an interesting paper at the February 19 meeting of Sibley College Student Branch, on Recent Developments in Mechanical Engineering.

At the March 6 meeting, A. R. Nottingham gave a talk, illustrated with lantern slides, on his original investigations in superheated steam. In the discussion which followed, Mr. Nottingham answered points raised by Professor Ellenwood and Messrs. Yoakum, Curtiss and Wegg.

LEHIGH UNIVERSITY

At the February 14 meeting of the Mechanical Engineering Society of Lehigh University, C. K. Baldwin, Mem.Am.Soc.M.E., gave an illustrated lecture on Belt Conveyors.

The following papers were presented at the March 5 meeting: Points of Interest about Anthracite Coal Mining, E. E. Finn (Student 1913); Our Present Measure of Steam Power Plant Economy a Delusion, or the Two Great Fundamental Laws and Boiler Economy, H. J. Williams (Student 1912); Wonders of High Frequency Currents, James Bailey (Student 1912).

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On February 20, William W. Dodge addressed the Mechanical Engineering Society of the Massachusetts Institute of Technology on How a Man Can Protect an Idea he Wants to Patent. He spoke briefly of the history and then outlined the steps to be taken to patent an idea. He also spoke of the relation of employer and employee in regard to patentable ideas, and concluded with the legal steps to be taken in cases of infringement and interference.

OHIO STATE UNIVERSITY

The Ohio State University Student Branch held a meeting February 26, at which T. S. Van Voorhis gave a discussion on the Silent Knight Motor, and L. Overturf presented a paper on the Description of and Aerodynamics Applied to the Wright Aeroplane. The interest of the meeting was manifested in the discussions which followed in which Messrs. Burrell, Tom, Stewart, Swarr, Cowser, Spencer, Neilan and Ehrlich took part.

PENNSYLVANIA STATE COLLEGE

Wm. T. Magruder, Mem.Am.Soc.M.E., delivered an address before the Pennsylvania State College Student Branch, March 8, on The Development of Mechanical Engineering in the Year 1911. The members of the civil and electrical engineering departments were invited to attend.

RENSSELAER POLYTECHNIC INSTITUTE

The January meeting of the Rensselaer Polytechnic Institute was merely a short business meeting at which the following officers were elected: W. D. Small, president, R. V. Dodge, vice-president, O. A. Van Denburgh, Jr., secretary, J. C. Hoar, treasurer.

At the February meeting the branch was addressed by A. M. Greene, Jr., Mem.Am.Soc.M.E., who gave a talk on Thermo, giving a new explanation of the term entropy and touching upon the available and unavailable energy in heated gases and vapors.

A special meeting was held on March 13, to which all the mechanical engineering students were invited. The meeting was addressed by W. D. Small, A. M. Greene, Jr., Mem.Am.Soc.M.E., Calvin W. Rice, Secretary Am.Soc.M.E., and R. L. Streeter, Assoc.Am.Soc.M.E. Mr. Rice gave an interesting talk on the value of engineering societies and spoke also of the work of other student branches, and the duties and problems of the graduate engineer. Professor Streeter then gave an illustrated lecture on iron, steel and ore handling machinery and motors, engines, producers, rolls, etc. used in the large steel works.

STATE UNIVERSITY OF KENTUCKY

Frank Daugherty, Jun.Am.Soc.M.E., addressed the State University of Kentucky Student Branch, on the Essentials of Power Plant Design, on February 14. He called attention to the advantages, where large power plants are developed, of the turbine over the reciprocating engine and the considerations involved in the choosing of units.

STEVENS INSTITUTE OF TECHNOLOGY

At a meeting of Stevens Engineering Society held jointly with the Polytechnic Student Section on February 23, William R. Hulbert, Assoc.Am.Soc.M.E., delivered a lecture on Aluminothermics, illustrated with lantern slides and practical demonstrations.

On February 24 the branch inspected the Eastern Division shops of the Brooklyn Rapid Transit Co.

A paper on Metal Working with Punches and Dies was presented by C. R. Barton (Student 1912) at the February 27 meeting. Discussion was offered by E. Byron, O. C. Röesen, C. C. Ross, L. H. Eggert and J. H. Bräutigam.

An inspection trip was made to the Atha Steel Works, Harrison, N. J., on February 28, and on February 29, Col. E. D. Meier, Past-President, Am.Soc.M.E., lectured on Modern Boiler Practice. The speaker was introduced by Dr. D. S. Jacobus, Mem.Am.Soc.M.E.

J. H. Vander Veer (Student 1913), submitted a paper on Electric Car Control at the March 5 meeting. This was followed by discussion by J. Strauss, C. R. Barton, G. L. Clouser, A. E. Bauhan and J. H. Vander Veer.

At the March 14 meeting, W. R. Warner, Past-President, Am.Soc.M.E., gave an address entitled, What are the Astronomers Doing? Mr. Warner was introduced by Dr. John A. Brashear, Hon. Mem.Am.Soc.M.E.

UNIVERSITY OF ILLINOIS

The University of Illinois Student Branch held an annual meeting on February 16, at which the following officers were elected: L. G. Smith, president, A. H. Agard, vice-president, C. A. Schoessel, secretary, M. I. Mix, treasurer. An interesting talk on The Labor Problem in Engineering was given by B. W. Benedict. At this meeting a committee was appointed to draft a new constitution, taking into consideration suggestions made by Calvin W. Rice, Secretary Am.Soc.M.E.

The branch was addressed, March 1, by Prof. O. A. Leutwiler, Mem.Am.Soc. M.E., who gave an illustrated lecture on The Development of Cranes, tracing the growth from the ancient lifting devices to the very large dock-yard cranes of the present day.

At the meeting held March 15, the following papers were presented: The Development of the Internal-Combustion Motor, C. W. Lincoln (Student 1914); Gas Producers, L. M. Mathews (Student 1912); The Automobile Engine, A. Elmendorf (Student 1914). A general discussion followed.

UNIVERSITY OF KANSAS

Papers on the Plant of the Topeka Water Works, E. A. Van Houten and Losses by Condensation in Steam Plants, L. L. Browne, were presented at the February 15 meeting of the University of Kansas Student Branch.

The branch was addressed by Professor Twenhoffel, on March 7, upon the Geology of the Earth's Crust.

At the March 14 meeting the following subjects were presented: The Tool System of the Santa Fé Railroad, M. C. Conley, The Weight per Horsepower of Gas Engines, L. E. Nofsinger, and The Future of the Gas Engine, Mr. Fierabend.

UNIVERSITY OF MISSOURI

The subject discussed at the March 4 meeting of the Student Branch of the University of Missouri was Foundry Practise. It was subdivided into five parts as follows: General Outline, G. D. Mitchell; Pattern Making, H. Mueller; Machine Molding, J. W. Haney; Hand Molding, I. Dunbar; Core Making, F. I.

Kemp. Prof. H. S. Philbrick, Jun.Am.Soc.M.E., and Prof. H. W. Hibbard, Mem.Am.Soc.M.E., followed with discussions, the latter also complimenting the branch on the excellent way in which the subject was handled.

UNIVERSITY OF NEBRASKA

A business meeting of the University of Nebraska Student Branch was held February 22, at which time the following officers were elected: B. R. Beckwith, president, W. H. Noelting, secretary, and P. S. Toney, treasurer. Prof. J. D. Hoffman was appointed honorary chairman to succeed Prof. C. R. Richards.

At the meeting on March 5, the subject discussed was Open-Feed Water Heater versus Closed-Feed Water Heater, E. E. Dale and M. C. Evans arguing for the former and R. J. Foster and Edmond Berger for the latter.

YALE UNIVERSITY

At a meeting of the Yale University Student Branch, held on February 6, Prof. F. R. Hutton, Honorary Secretary Am.Soc.M.E., delivered an illustrated lecture on the subject of The Prevention of Accidents in Factory and Shop.

NECROLOGY

GEORGE WALLACE MELVILLE

Rear Admiral George Wallace Melville, U. S. N., Retired, died at his home in Philadelphia, Pa., March 17, 1912, at the age of seventy-one. An account of his life is published elsewhere in this issue of The Journal.

W. F. BUCK

W. F. Buck, superintendent of motive power of the Atchison, Topeka and Santa Fé Railway, with headquarters at Chicago, Ill., died while traveling through San Bernardino County, California, on January 31, 1912.

Mr. Buck, who was born at St. Andrews, N. B., on June 9, 1863, received his education in the public schools of that community, entering railway service in 1882 as an apprentice in the shops of the Intercolonial Railway, where he received a practical mechanical training. In 1886 he severed his connection with this road and entered the employ of the Northern Pacific Railway as roundhouse foreman at Staples, Minn., and in 1895 he was promoted to the position of general foreman first at Missoula, Mont., and later at Helena, Mont. Mr. Buck steadily advanced in his profession, becoming master mechanic in 1902 of the Rocky Mountain Division of the Northern Pacific Railway, with headquarters at Missoula, and in 1904 of the Arizona division of the Atchison, Topeka & Santa Fé Railway, at Needles, Cal. Several years later he was appointed mechanical superintendent of the Eastern Grand Division of the same company, with headquarters at Topeka, Kansas, and in 1908 entered upon the work in which he was engaged at the time of his death.

Mr. Buck was always deeply interested in his profession and was the designer of a number of practical mechanical devices for railroad work, including a locomotive superheated and a locomotive external throttle.

MILTON P. HIGGINS

Milton P. Higgins, for many years superintendent of the Washburn Shops of Worcester Polytechnic Institute, and widely recognized as the originator of this plan of education as well as for his ability in the industrial and commercial world, died at Worcester, Mass., on March 8, 1912.

Mr. Higgins was born December 7, 1842, in Standish, Me., and early in his boyhood showed his liking for machinery. At the age of seventeen he entered the shops of the Amoskeag Manufacturing Company of Manchester, N. H., and while devoting himself ardently to his work, managed to apply himself to study in the evening and finally to enter and to graduate from Dartmouth College, wholly through his own efforts. After graduation he became a draftsman at the Washburn & Moen Wire Works in Worcester, under the late Charles Hill Morgan, with whom he was associated later for many years at the Worcester Polytechnic Institute.

It was at this time that the plan of Mr. Ichabod Washburn for a shop that would train the students and at the same time be a commercial success was put into practice, and Mr. Higgins was selected by Mr. Morgan and other trustees of the Worcester Polytechnic Institute to carry it out. Industrial educators everywhere and those interested in such matters know how well Mr. Higgins succeeded, building up several lines of business for which he himself designed the machinery, such as machine tools, special grinding apparatus, and the hydraulic elevator of the direct-acting plunger type, and the work of its graduates has been a constant testimony to the thoroughness of administration during the twenty-eight years he was superintendent.

Mr. Higgins' active mind had time for other projects and in 1885 he organized, with George I. Alden, also of Worcester Polytechnic, the Norton Emery Wheel Company, the personnel of which has been altered only by Mr. Higgins' death. The development of the great abrasive industry of the present Norton companies is due largely to the foresight and judgment of Mr. Higgins.

In 1889 Mr. Higgins was granted a year's leave of absence from the Washburn Shops, so that he might organize the shops of the Georgia School of Technology started at that time in Atlanta, Ga., and which is still in successful progress. He was also called upon to plan the shops of the Miller Manual Labor School of Virginia.

In 1896 Mr. Higgins resigned his connection with the Worcester

Polytechnic Institute, although through his appointment later on the Board of Trustees he still maintained his interest in it, and organized the Plunger Elevator Company, which had its inception in the work of the school. Mr. Higgins' genius for organization also showed itself in his formation of the Worcester Pressed Steel Company in 1904.

At the time of his death, in addition to his association with the companies already described, Mr. Higgins was president of the Manchester Supply Company of Manchester, N. H., and of the Sanford Riley Stoker Company of Providence, R. I. He was a director of the Mechanics National Bank of Worcester, and was president of the Board of Trustees of Worcester Polytechnic Institute. He was a charter member of the Society for the Promotion of Industrial Education.

Mr. Higgins was a charter member of this Society and served as one of its vice-presidents from 1901 to 1903. In 1899 he presented before the Society two papers on the Education of Machinists, Foremen and Mechanical Engineers, giving his educational theories, which created wide interest. The Society was represented at Mr. Higgins' funeral by Honorary Vice-Presidents G. I. Rockwood, A. L. Smith, H. B. Smith, C. A. Read, Geo. I. Alden and Paul B. Morgan.

ALBERT W. JACOBI

Albert W. Jacobi was born August 24, 1861, in Newark, N. J. His professional service began in 1878 when he started as an apprentice in the machine trade at the Hewes and Phillips Iron Works of that city. His first two and a half years were spent on the Porter-Allen engines which were at that time built at these works. When Mr. Porter removed to Philadelphia he was placed in charge of the construction of two small engines, and assisted in the erection of numerous machine tools. He then assisted in the drawing room in which department his apprenticeship was completed. During his stay here he realized that his technical education had been much neglected, and therefore decided to attend the Ohio State University. While at college he assisted in designing and constructing the steam heating system in the chemical laboratory as well as in other minor constructions. Upon graduation in 1884 he was reengaged by his former employers, his attention now being confined to machine tools, many of which were of heavy type, to steam engines, boilers and special machinery. He later became identified with the American Lead Pencil Company of Hoboken, as superintendent, but was obliged to give up this position on account of ill health. In 1901 he became connected with the Gould and Eberhardt Machine Tool Company of Newark, as chief engineer, but three years later relinquished this for a position as superintendent of the Automobile Club of America. In 1908 he entered into private practice as a consulting engineer, in which capacity he was engaged until the time of his death, February 18, 1912.

JOHN G. OULD

John G. Ould died at his home in Brooklyn, N. Y., on December 21, 1911. He was born April 2, 1863, in Falmouth, England, and was educated in the private schools in England and in the Kensington Science and Art School. He also took courses in Pratt Institute and in the Polytechnic Institute of Brooklyn, N. Y. During his youth he was an apprentice in the English shops of A. & W. Robertson, Victoria Docks, London, builders of marine engines; and Waddington and Company, Liverpool. In May 1885 he took the Board of Trade examination for second class engineer, and for the following five years spent most of his time at sea. During this period he was chief engineer of the steamship Montana, sailing between England and Buenos Aires; chief engineer of the steamship Condor, covering the same route; and chief engineer of the steamship Euxine, from England to Constantinople. In June 1890 Mr. Ould came to New York and obtained employment with Seabury and Company and later with the firm of Mitchell and Boyeson as foreman in charge of repairs. He was subsequently engaged as assistant engineer with the Western Union Company and with Ball and Wood Company. In February 1897 he superintended the installation of the mechanical plant of the Polhemus Memorial Clinic and held the position of superintendent and chief engineer of that institution until the time of his death.

EDWARD K. SANCTON

Edward K. Sancton was born in St. John, New Brunswick, June 11, 1840. He was indentured as an apprentice to the Fleming Foundry, machinists and engineers, where he served until 1861. On leaving St. John he entered the employ of the Morgan Iron Works in New York City and was soon placed in charge of the construction and erection of the engines and machinery for the double-turreted monitor, Onondago, and on the completion of this work was made foreman of one of the departments. He later became engineer on the steamship Fulton, plying between New York and Southampton, this steamer being the pioneer in the attempt to establish a transatlantic line under the American flag subsequent to the Civil War. On the failure of the steamship company profitably to maintain transatlantic service, he returned to shop work and was employed by Fletcher and Harrison, of New York. During this period George W. Quintard, former proprietor of the Morgan Iron Works, sold this establishment and organized a new marine engine works, called the Quintard Iron Works, of which Mr. Sancton was made foreman of the machine department and assistant to the manager. In this position he supervised the construction and erection of many large pumping and marine engines. In the year 1881 he entered the employ of E. D. Leavitt, Jr., consulting and designing engineer, Cambridge, Mass. This engagement was fruitful of an extended experience, the inspection covering work constructing with I. P. Morris Company, in Philadelphia, the Dickson Manufacturing Co., Scranton, Pa., and others, resulting in the reorganization of the Dickson Company in 1883, in the appointment of Mr. Leavitt as consulting engineer, with Mr. Sancton as assistant superintendent and works manager. He continued in this position until 1895 when he was called by Fraser and Chalmers, Limited, of Erith and London, England, to assume the position of general manager of their English works. In 1910 he was appointed a director of this company and took an active interest in their affairs until his death on December 26, 1911.

FRANCIS H. STILLMAN

Francis H. Stillman, president of The Watson-Stillman Company, and a prominent figure in machine tool and engineering industries, died suddenly on February 16, 1912, at his residence in Brooklyn.

Mr. Stillman was born in New York on February 20, 1850, and was graduated from Yale in the class of 1874 with the degree of B.S. On leaving college, Mr. Stillman first associated himself with the Cottrell Printing Press Company, at Westerly, R. I. In 1883 he became president of the firm of Watson & Stillman which succeeded Lyons & Company, and in 1904 the firm was incorporated as The Watson-Stillman Company, Mr. Stillman remaining president up to the time of his death. Under his direction the firm early became prominent in the hydraulic engineering field and has a large and active plant in Aldene, N. J. Mr. Stillman was also president of the Bridgeport Motor Company and of the Pequannock Commercial

Company, and a director of other manufacturing firms. He was one of the recognized pioneers in hydraulic machine tool construction.

Mr. Stillman was a member of the Engineers Club, the Hanover Club of Brooklyn, and the treasurer as well as a director of the National Association of Manufacturers. He organized and was the first president of the Machinery Club of New York, and was also the first president of the National Metal Trades Association.

Mr. Stillman was actively interested in the Gas Power Section of the Society, as well as in the work of its main body, and was serving as the chairman of its executive committee at the time of his death. At a meeting of the committee on February 29, 1912, the following tribute was spread upon the minutes:

> The Committee desires to enter upon its records something of their appreciation of the long and effective services of Mr. Stillman as a member of the Section and of the Executive Committee, and finally its Chairman. He died while carrying the burdens and privileges of that office.
>
> Mr. Stillman brought to the duties of shaping the policy of the Gas Power Section of the Society, his wide experience in administrative affairs, his shrewd and clear-sighted judgment, and that genial kindness of spirit which was one of his greatest charms. In all the difficulties and problems of starting such an enterprise, his abilities and his assiduity of service were splendid factors in bringing the Gas Power Section to its present standard of usefulness and effectiveness. His associates will miss his high standard of business integrity, his keen personal interest in the duties which he had to do, and his willingness to take trouble for the things which he thought worth while. His colleagues will miss also his friendship and the pleasure of intimate association with him.

The Society was represented at Mr. Stillman's funeral by Honorary Vice-Presidents Fred R. Low and Jesse M. Smith.

JOHN BURKITT WEBB

John Burkitt Webb was born in Philadelphia, Pa., November 22, 1841, and entered the Philadelphia high school at the age of thirteen. Although kept at work in a store for some years after leaving school, he was always in pursuit of mechanical and physical problems. His father having patented a windmill, young Webb set about to determine the speed and angle of sails giving the maximum efficiency, and thereby was led to study Hutton's Mathematics, Loomis's Calculus, and other works on higher mathematics. Finally he left the store and went to Bridgeton, N. J., where with Oberlin Smith, he formed a small company to make an electro-magnetic apparatus for playing organs automatically. The enterprise proved too great, however, for the means at hand, and was therefore abandoned. Mr.

Webb then went to work in a pipe-mill and built a trip-hammer which ran many years and greatly expedited a part of the manufacture. At the outbreak of the war business became so dull that he sought employment for a year and a half with a medical journal in Philadelphia, meanwhile studying drawing in the evening at the Franklin Institute. In the summer of 1863, Mr. Webb again started in business at Bridgeton, in partnership with Mr. Smith, building special machine tools. In 1869, he entered the University of Michigan and after graduation was engaged as assistant in the civil engineering department. In 1871, Professor Webb accepted the charge of the Civil Engineering School, newly established in that institution. He held this position for eight years, during which time he made a trip to Europe for the inspection of scientific schools and for the purchase of apparatus, started a small astronomical and meteorological observatory for the school, delivered several courses of original lectures, partially developed his method of treating bridge stresses, and constructed various pieces of apparatus.

In 1879 he resigned his professorship to pursue a course of advanced scientific study abroad, and spent over two years attending lectures on pure mathematics, mathematical physics, logic, etc., and in experimental work in physical laboratories at Heidelberg, Göttingen, Berlin and Paris. A year was spent in Professor Helmholtz's laboratory constructing apparatus for, and working at, the then undeveloped action of an oscillating current through coils of wire and electrolytic solutions, with which considerable progress was made. His skill with tools secured him the privilege of using the apparatus in the instrument-maker's shop of the university, and before leaving Berlin he was made a member of its Mathematical Society. Nearly a year was spent in Paris attending lectures at the Sorbonne and College de France and in examining technical schools, collections and methods there and in other parts of France.

In 1880 Professor Webb was appointed to a new chair of applied mathematics at Cornell University. During his occupancy he delivered original lectures on thermodynamics, mechanism, drawing and drawing instruments, acted as judge at the International Electrical Exhibition of 1884; invented a draught gage which was officially used at this exhibition, and an inertialess steam-engine indicator which excited much attention at the American Association meeting at Montreal, and published an exhaustive article on Belting to Connect Shafts which are not Parallel and do not Intersect.

Professor Webb was called to the position of professor of mathematics and mechanics at Stevens Institute of Technology in 1886. He retired in 1907 under the Carnegie Foundation Pension Fund, and had since that time been engaged in private experimental and consulting engineering work.

In 1888 he originated his floating dynamometer which is a most convenient and perfect device for measuring the power given out or absorbed by motors, dynamos and other machines. In 1892 he invented the viscous dynamometer, which is an absorption dynamometer depending on fluid friction, or viscosity, between rapidly moving surfaces. In 1900 he invented the dynamophone, which is a transmission dynamometer measuring the twist of a shaft carrying power, by a simple telephonic method of great accuracy and reliability.

Professor Webb was a member of the American Association for the Advancement of Science, American Mathematical Society, and the University of Michigan Round Table. He died of pneumonia in New York, February 17, 1912.

FREDERICK W. WOLF

Frederick W. Wolf, who died in Chicago, Ill., February 17, 1912, was born in Duehren, Germany, November 27, 1837. His early education was obtained in the high schools of Weinheim, near Heidelberg, but before being able to enter a technical college he was obliged to take up some specific trade, and in 1852 entered a locksmith shop in Nuremberg, Bavaria, to serve there as an apprentice. Later he went to Switzerland, where he worked in a machine shop, returning to Berlin in order to enter the employ of a sugar machinery manufacturer. At the age of twenty-one he was sent to erect a beet sugar factory 300 miles southwest of Moscow, where he encountered a great many difficulties, being obliged to employ men who could speak only the Russian language. After successfully completing this installation he pursued the work of erecting machinery in different German cities, until he was able to enter the technical college at Carlsruhe in Baden, where he studied mechanical engineering for four years, his last year there being in the capacity of assistant to the professor. After completing his education he was employed by the Guppy Machine Shop, an English firm in Naples, Italy, to design engines for the Italian warships. In 1866 he came to New York and obtained employment as a draftsman in a number of different firms. The next year he went west and for a short period was master mechanic for the Pere Marquette

Railroad Company, at Marquette, Mich. From 1867 to 1875 he was in business as consulting engineer and architect in Chicago. Realizing the immensity of the future in artificial refrigerating machinery, Mr. Wolf purchased in 1875 the right to manufacture the celebrated Linde ice machine, patented by Prof. Carl Linde of the University of Munich. The first Linde machine erected in the United States was imported by Mr. Wolf in October 1882, and installed in the Wacker & Birk Brewery, Chicago, where it still remains. Another machine was imported and erected in the Schlitz Brewery at Milwaukee, but on account of the many difficulties surrounding the importing of these machines, Mr. Wolf decided to begin their manufacture in this country. In 1887 the Fred W. Wolf Company, of which Mr. Wolf was president until his death, was incorporated and continued the successful manufacture of refrigerating machinery.

About 1897, spurred on by the opportunities which presented themselves, and his early training in the erecting of beet sugar factories, the Fred W. Wolf Company, under the direction of Mr. Wolf, installed a number of beet sugar factories in Michigan, which were very successful. On account, however, of the growth of the refrigerating industry, the manufacture of beet sugar machinery was abandoned about 1900, and since that time all the energies of the Fred W. Wolf Company have been devoted to the building and installing of the Wolf-Linde refrigerating and ice-making systems. Over 1200 machines have been built and erected under the direct supervision of Mr. Wolf, and he, without doubt bears the distinction of being the father of the refrigerating industry in the United States.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for the Bulletin must be in hand before the 12th of the month. The list of men available is made up of members of the Society, and these are on file in the Society office, together with names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

0151 Member, having engineering sales office handling power equipment and miscellaneous machinery as direct representative of a number of well-known manufacturers, desires to make arrangements, preferably with a young man, to turn over part of line to a suitable person who will have the benefit of all the facilities of the office and is in position to work on a commission basis. Excellent opportunity for a young man capable of building up new business for manufacturers who have not previously been represented in this market. Location, New York.

0152 Three salesmen with engineering experience to cover New Jersey, Ohio and Canadian territory for a prominent manufacturer of ball bearings. Salary depends on man.

0153 Massachusetts concern, manager of shop in manufacture of stand pipes, water tanks and pen stocks. Young engineer, capable of estimating costs of water tanks, towers, etc.

0154 Factory superintendent, for concern manufacturing electrical specialties, and ignition apparatus for gasolene engines. Wants up-to-date man, well educated in mechanical and electrical branches. Location, Massachusetts.

0155 Ohio concern wants high grade men in sales department in application of rubber goods, involving an intimate knowledge of engines, boilers, pumps, transmission machinery, pneumatic tools, etc. Prefers men not over 30 years of age and capable of training to this work.

0156 New York concern wants salesmen of machinery and steam specialties. Men with technical education preferred and two or three years' experience.

0157 Ohio concern desires to secure services of technical graduate who is sufficiently familiar with gas engine work in the smaller sizes to assume successfully the position of general foreman with a view of working up to superintendent. Prefers that applicant have two or three years' practical experience.

0158 Special representative to advance interests in the mechanical rubber goods line, with western mining interests from Mexico to British Columbia, superior high grade man. One preferred who has had mining and mechanical training making him familiar with plants, people, etc., must be a good "mixer." Will pay salary which will assure a capable man; around age of 30. Will require a great deal of traveling.

0159 Ohio concern desire superintendent with practical shop experience and thorough knowledge of operation of all kinds of tools in both machine shop and foundry; must be capable of handling men; ability in design of jigs, able to reduce costs and increase output.

MEN AVAILABLE

381 Mechanical engineer, age 34, technical graduate, 12 years' extensive experience in design, construction, and operation of steam turbines, condensers, power plants and general machinery. Familiar with electrical work and modern industrial plants. Desires position where executive ability and broad engineering experience can be used to advantage.

382 Professor of experimental engineering, age 33. Eight years' experience in teaching; wide engineering experience. Desires a change to professor of mechanical engineering.

383 Works manager, long experience on light manufacturing involving interchangable parts. Competent to organize all departments of manufacturing plant along modern lines.

384 Sales manager; main experience in boilers, engines and complete power-plant equipment, good general training both technical and business. Wide acquaintance with men worth while in middle and eastern states. Cornell University, M. E.; Mem. Am. Soc. M.E.

385 Young mechanical engineer, technical graduate, shop experience particularly in erecting and testing of hydraulic machinery, desires position with an engineer or with manufacturing concern in erecting, engineering, or sales department.

386 Associate, mechanical, and erecting engineer, technical graduate, age 32, married, three years' experience drafting, two years' erecting plate and wire mills, five years' mechanical engineer of steel car company; at present superintendent of small company. Desires to make a change in the near future.

387 Technical engineer with varied experience, German and American, desires position as assistant to the president of some large enterprise requiring engineering research, or private secretary to man of affairs.

388 Professor of wide experience would be pleased to report on any subject requiring a visit to foreign countries.

389 Factory manager of a concern employing 300 men, would consider making a change. Age 31 years. Graduate Worcester Polytechnic Institute. Familiar with practical cost and production systems. Thorough knowledge of modern grey iron foundry practice. Three years' sales experience.

390 Sales manager, wide experience in boilers, engines and general power-plant equipment lines, desires connection with firm who can appreciate high-grade result producing work. Technical graduate.

391 Graduate U. S. Naval Academy, with experience at sea, later with large concern as supervising engineer in connection with the manufacture of fans, blowers, electric motors, the preparation and issuance of technical literature in connection with same and general charge of sales, desires position as sales manager. Salary $5000.

392 Mechanical engineer, Junior member, German, 29 years old, graduate of the Polytechnicum, Munich. Experience in design and layout of coal and coke handling plants here and abroad. Now connected with one of the largest by-product coke oven concerns in New York City; desires position where experience will be of value or as assistant to the engineer, manager or superintendent in business where there are good chances for advancement.

393 Member, married, graduate with advanced degree prominent eastern technical school; foreign study in technical school, one year. Three years' practical experience. Ten years professor in mechanical engineering department of eastern university, author of text books, desires to make a change. Teaching preferred. Specialties: descriptive geometry, machine design, automobile design and tests.

394 Member, 18 years' experience wants position as superintendent, assistant works manager; age 35, married, practical mechanic, technical education, good hustler and organizer with experience including heaviest class of machinery. At present employed as superintendent.

395 Member, technical graduate, age 34, experience in shipbuilding, steam and gas power machinery, and in teaching these and other mechanical engineering subjects. Prepared to take charge of work connected with technical design and estimates of cost for construction, or problems of economy in existing plants.

396 Member, technical graduate with machine shop training and 15 years' experience in the design, purchasing material and construction of power plants for electric railways, lighting and industrial works, some experience in appraisal work and knowledge of French, German and Swedish; desires position with consulting or construction engineers or manufacturing concern with greater scope for application of experience than present position offers. Would undertake the investigation of plants.

397 Cornell University 1906; Junior member, shop, motor truck, and drafting-room experience. Five years' teaching mechanical engineering. Wishes sales position. Any location.

398 Student member, college graduate in mechanical engineering, experienced in mechanical, structural, architectural and automobile designing and estimating, broad experience in steel mill, experimental engineering, and testing of all kinds of engines, boilers, gas producers, etc.; short while assistant instructor in experimental engineering in college. Desires position with engineering corporation or consulting engineer. Best of references furnished.

399 Graduate engineer, at present manager of plate metal working plant, desires similar position or as assistant manager of larger plant. Broad experience in manufacture of boilers; in engineering and executive departments.

400 Sales engineer, Member, desires to connect with concern requiring mechanical or electrical knowledge combined with the advantage of manufactur-

ing experience that is essential to marketing product and securing its specification with architects, engineers and large manufacturing plants.

401 Chief engineer and designer with 12 years' experience on gas engine and automobile work, technical graduate. Member of Gas Power Section. At present employed, but desires change to larger field of usefulness with either automobile or gas engine manufacturer.

402 Graduate engineer, 38 years old, 15 years' shop and office experience manufacturing iron and steel products, desires position as works manager or superintendent.

403 Junior desires responsible position; age 29, married, at present mechanical engineer in charge of drafting department of large corporation; wide experience in design and construction of laundry, chemical, centrifugal and drying machinery, also fans and blowers; familiar with tests and experiments, cost systems, etc.; able to handle men and to direct them.

404 Junior member desires assistant or full professorship in mechanical engineering; preference for experimental engineering and laboratory work but can cover any kind of mechanical engineering subject. Minimum salary $2500.

405 Engineer of varied experience; cement mill expert; experience in dross mills, hydraulics, electricity, steam, gas and power-house work; reliable, systematic and good organizer.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

ACCIDENT PREVENTION AND RELIEF, F. C. Schwedtman and J. A. Emery. *New York, 1911.*

AMERICAN WATER WORKS ASSOCIATION. Proceedings, 1st–6th, 1881–1886. *Buffalo, 1881–1886.* Gift of Engineering News.

ANNALES DES PONTS ET CHAUSSÉES. Tables générales de la partie technique, 1831–1910. *Paris.*

L'ANNÉE SUCRIÈRE 1909–1910, R. Teyssier. *Paris, 1911.*

APPLIED HEATING AND VENTILATION, WITH CHARTS AND FORMULAS, J. M. Harrison. *New York, 1911.*

ARMOUR ENGINEER. Vol. 3. *Chicago, 1911.*

AUDEL'S ANSWERS ON AUTOMOBILES FOR OWNERS, OPERATORS AND REPAIRMEN, Gideon Harris. *New York, 1912.* Gift of Theo. Audel & Co.

BASES ET MÉTHODES D'ETUDES AEROTECHNIQUES, L. Ventou-Duclaux et M. Robert. *Paris, 1911.*

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Every librarian or editor of a technical paper will welcome with great joy the issuance of this book. One of the most difficult things that a librarian has to do is to find biographies of living persons, and there has not up to this time existed a biography of living men of science which was international in scope. This book should be particularly interesting to engineers, as for the first time engineers are included among men of science in a biographical dictionary. The biographies of about 100 American engineers are included. In each case there is given, in addition to the ordinary facts found in all biographical dictionaries, the present address of the person, his present position and the publications which he has made, thus forming a valuable bibliography of recent works of science. The work also includes a list of the leading universities of the world, with the names of the professors in all of the important subjects. The price ($2) is remarkably reasonable as compared with works of a similar character.

EXCHANGES

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UNITED ENGINEERING SOCIETY

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The Society wishes to thank Engineering News and the American Electric Railway Association for the large number of interesting books and pamphlets which they have placed at the disposal of the United Engineering Society Library.

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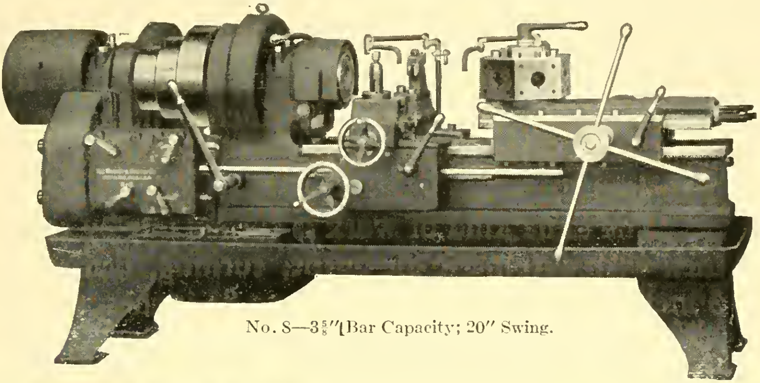

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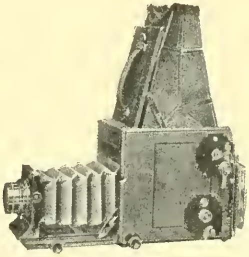

The Graflex-Steinheil Combination

with which perfectly sharp pictures of moving machinery may be secured indoors.

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Focal Plane Shutter: having 50% higher speed than other types, and giving superior light distribution.

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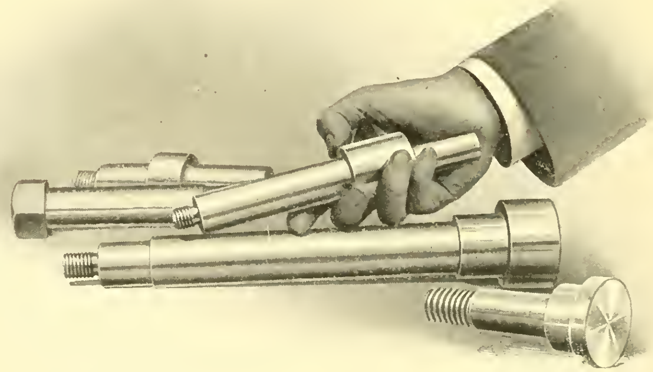
HARTNESS FLAT TURRET LATHE

Working Range for Bar Work

THE work shown on this page is the product of the 2 x 24-inch Flat Turret Lathe with the automatic die outfit (outfit D). This outfit gives the highest efficiency on such work. It turns all diameters up to 2¼ inches and all lengths up to 24 inches, and cuts all U. S. standard screws from ⅜ to 1¼ inches, inclusive, by sixteenths. (Whitworth, Metric or V standard furnished if desired.)

The same kind of work is turned out by the 3 x 36-inch with automatic die outfit; turning diameters from 3 inches down, and lengths up to 36 inches, and cutting screw threads from 1 to 2 inches, inclusive, U. S. standard. (Whitworth, Metric or V standard furnished if desired.)



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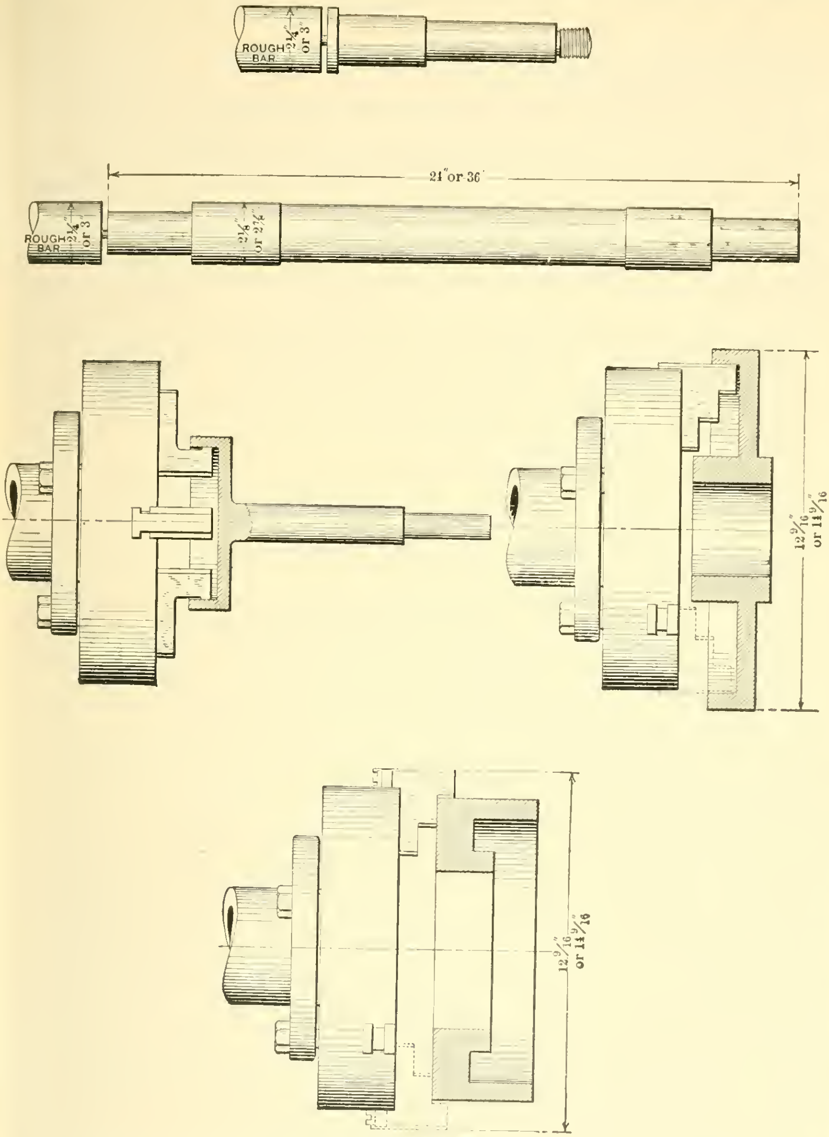

Examples indicating working range and character of work covered by both machines

Machine Company

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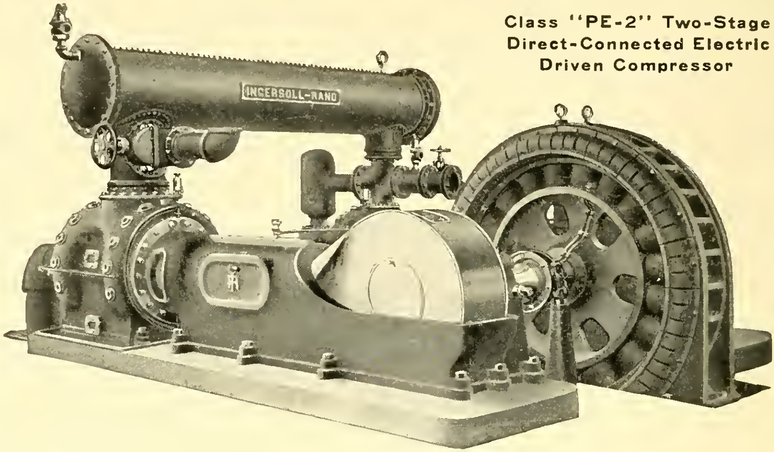

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Direct-Connected Electric
Driven Compressor

This Compressor Has the Highest Over-All Efficiency at Present Attainable in Power Driven Types

Measured by the ratio of compressed air output to E. H. P. (electrical horse-power) input, the Ingersoll-Rand Class "PE" Direct-Connected Electrical Air Compressor shows the highest economy ever realized in power driven compressor practise.

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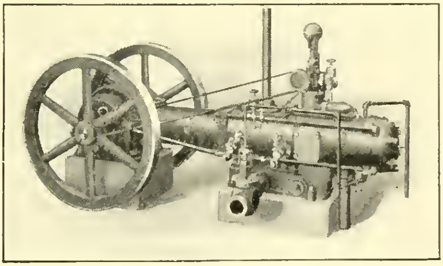

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AIR COMPRESSORS
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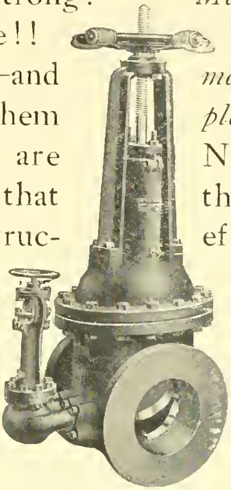

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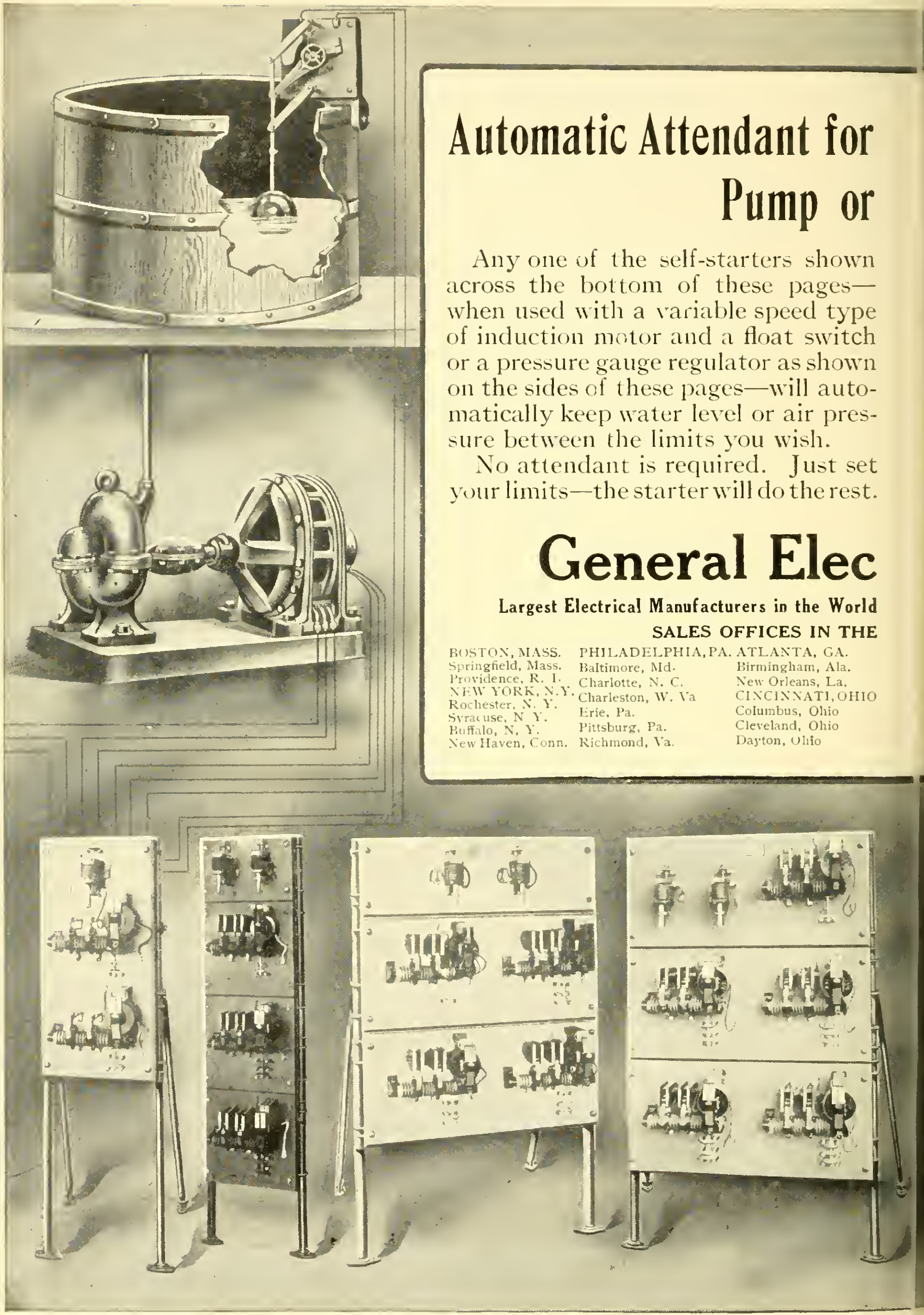

Automatic Attendant for Pump or

Any one of the self-starters shown across the bottom of these pages—when used with a variable speed type of induction motor and a float switch or a pressure gauge regulator as shown on the sides of these pages—will automatically keep water level or air pressure between the limits you wish.

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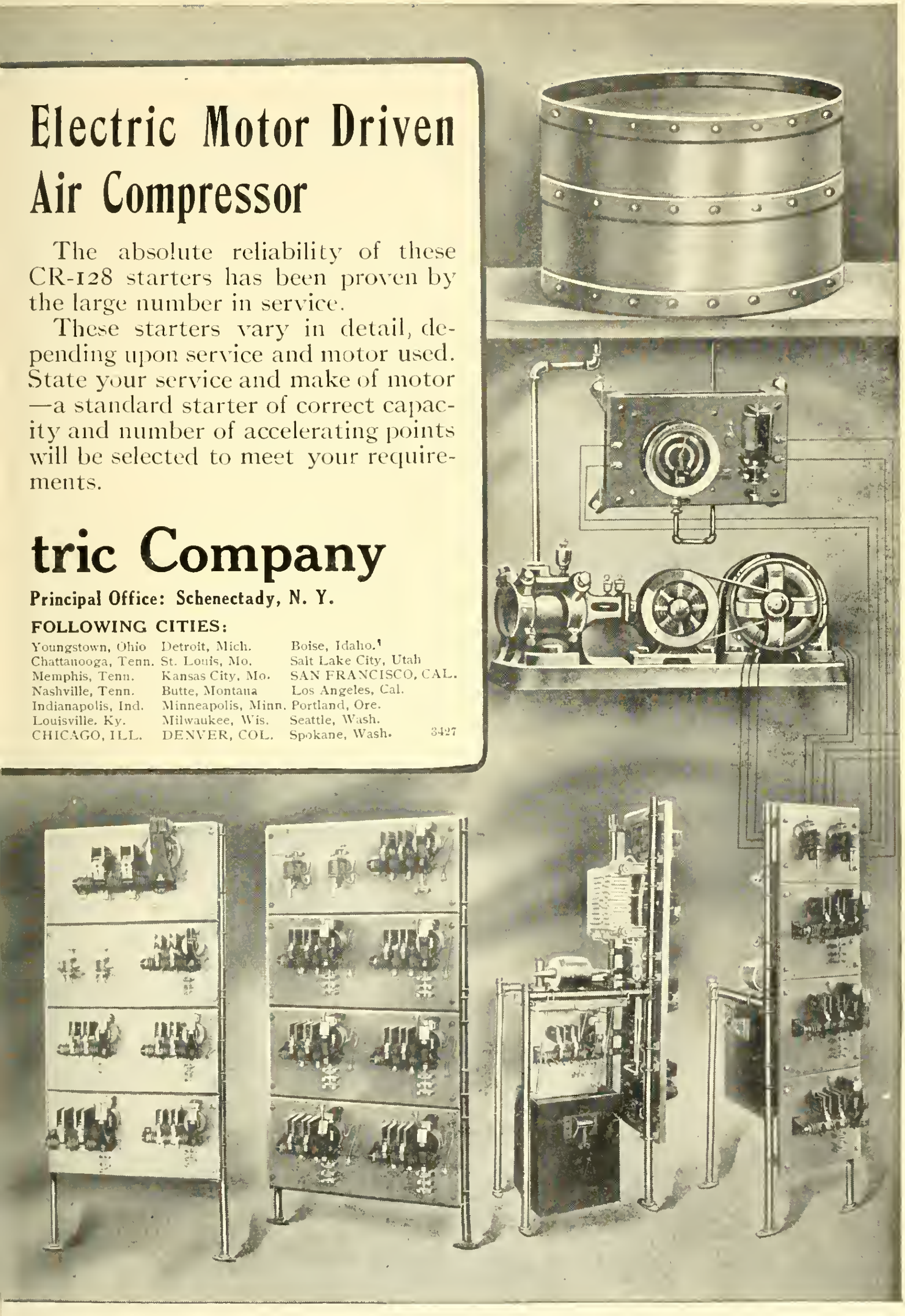

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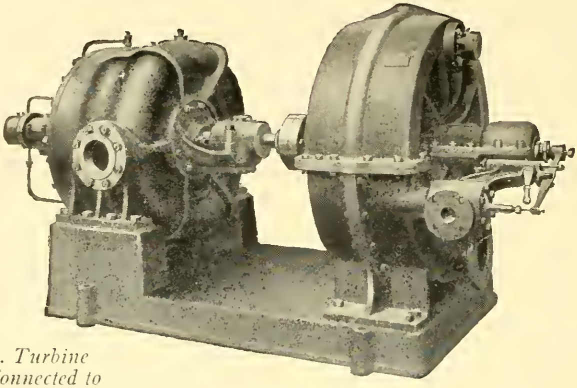

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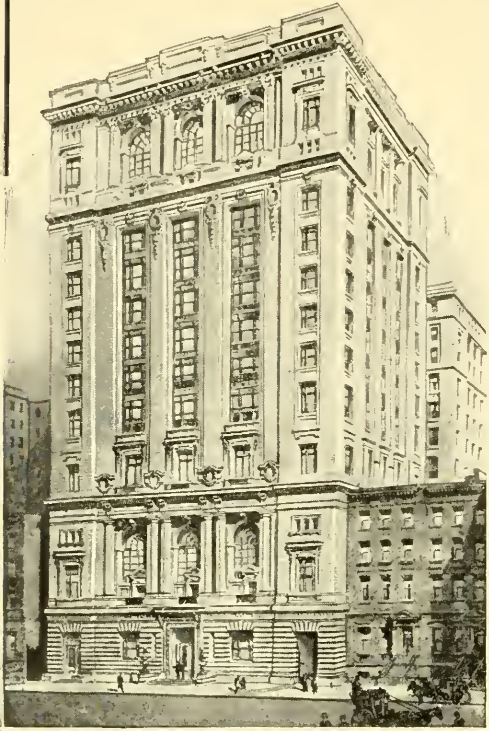

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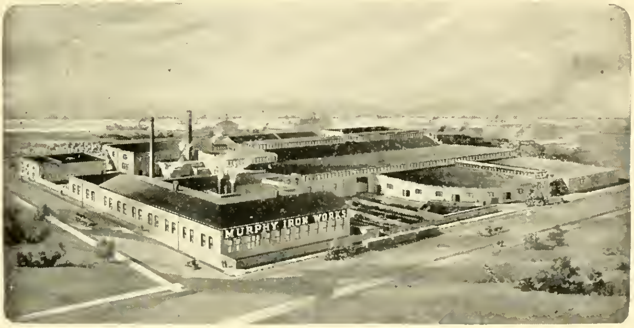

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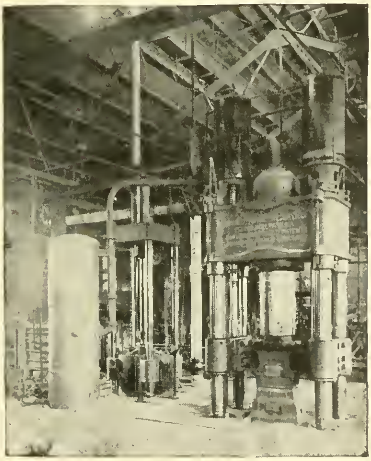

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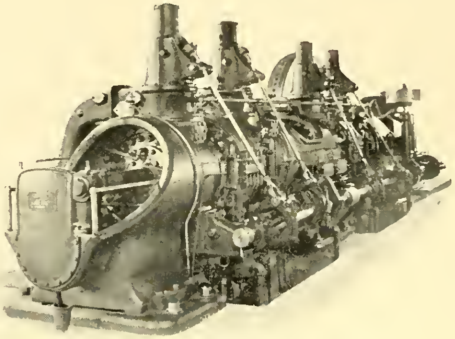

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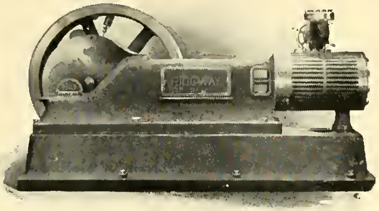

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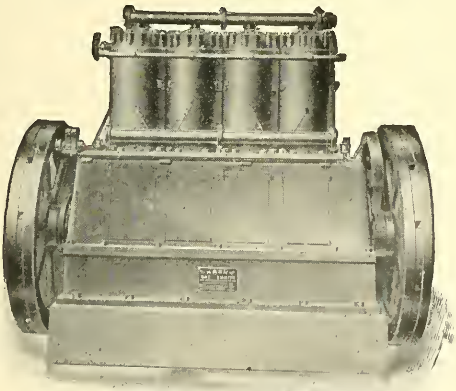

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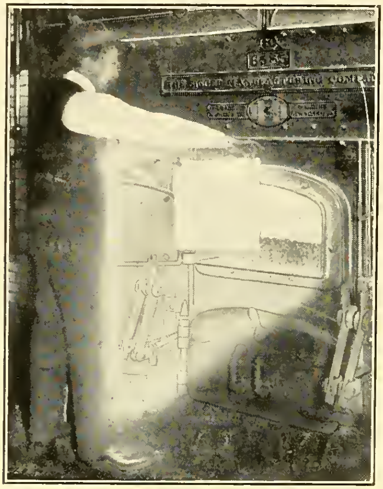

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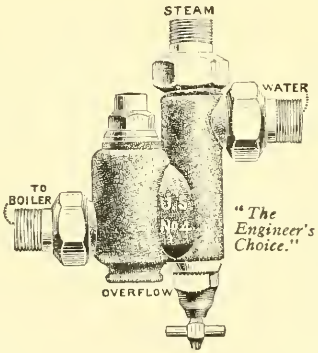

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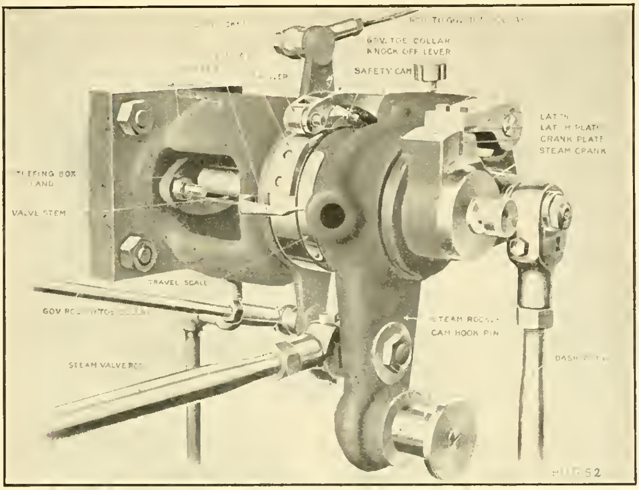

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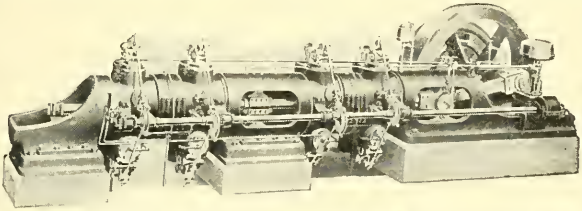

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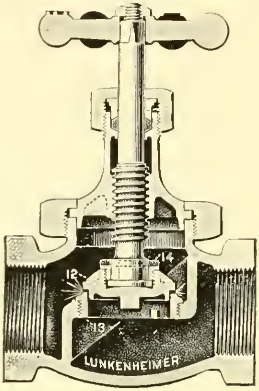

A valve that has sufficient strength; made of materials best suited for steam use; faultless workmanship; all parts renewable; seating surfaces regrindable, and the scientific construction of the disc and seat insures durability, as it minimizes the wear on the seating faces, keeps them free from scale or dirt and eliminates water-hammer.

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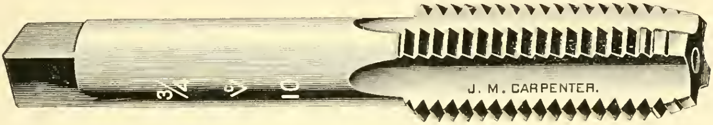

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Notice the improved edge construction which is the outcome of years of effort to overcome edge troubles.

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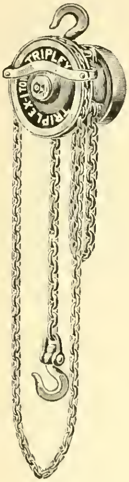

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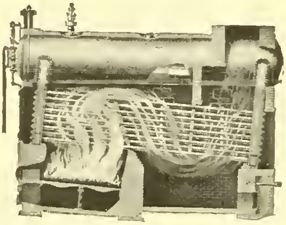

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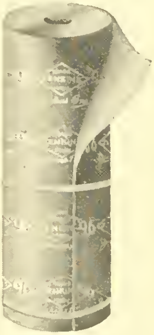

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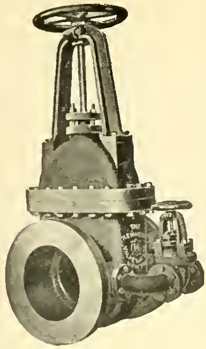

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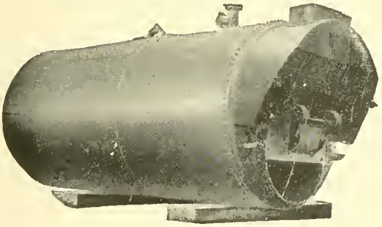

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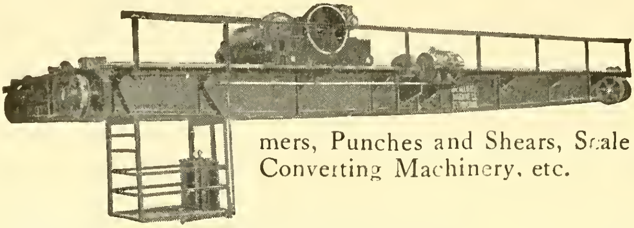

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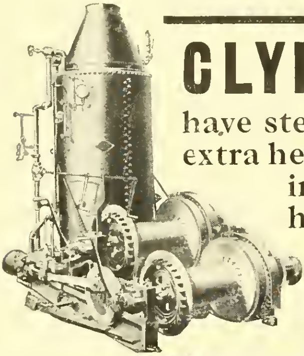

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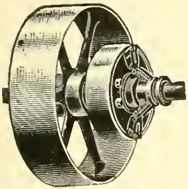

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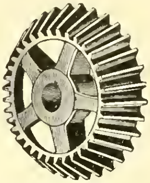

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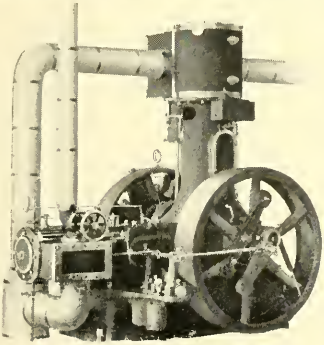

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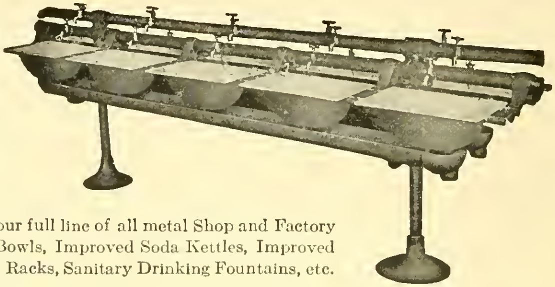

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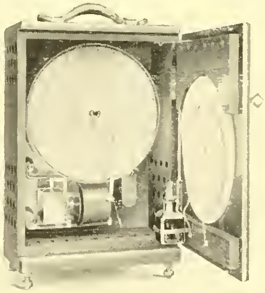

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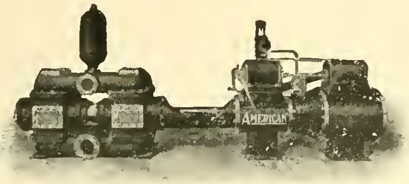

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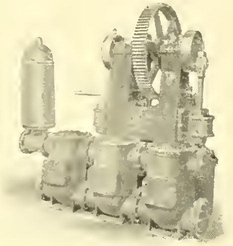

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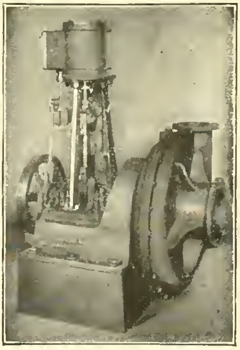

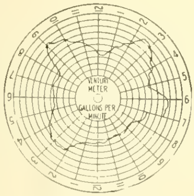

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